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*TREES, STARS
AND BIRDS*
Moseley

TREES, STARS, AND BIRDS

A BOOK OF OUTDOOR SCIENCE

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NEW-WORLD SCIENCE SERIES

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TREES, STARS AND BIRDS

A Book of Outdoor Science
by

EDWIN LINCOLN MOSELEY, A.M.

Head of the Science Department

State Normal College of

Northwestern Ohio

ILLUSTRATED IN COLORS

*from paintings by Louis Agassiz Fuertes
and with photographs and drawings*



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For the social and moral welfare of the human race it is necessary that our environment provide means for the satisfaction of the fundamental instincts of man, and in the opinion of many the desire to come into contact with Nature and to understand the phenomena and facts of Nature about us cannot with safety be neglected in the instruction of the young. Professor Moseley's *Trees, Stars, and Birds* covers three fields of Nature that have a perennial interest for the human mind and brings to the help of teachers who lack special training in outdoor science the wide knowledge and teaching experience of the author. Since the motto of the World Book Company is "the application of the world's knowledge to the world's needs," editor and publisher have pleasure in offering to the schools a text that promises to be useful in helping to satisfy a need that has its origin deep within the nature of man

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PREFACE

THIS book is designed to encourage students to observe and think. It may also furnish some information about trees, birds, and heavenly bodies which will enhance the pleasure of living wherever these things can be seen. The language is simple enough for students in the sixth or seventh grade, the facts important enough for more mature students.

Part One may well be studied in the fall, Part Two in winter, and Part Three in spring, but it would be a mistake to restrict the study of any part to a single season, or to attempt to finish one part before taking up the next. In order to become familiar with the planets and brightest stars the student should view the heavens at different seasons. The trees and birds also change their appearance as the seasons change. They should be observed at all times of the year.

The student who is well started in nature study is likely to continue his outdoor observations, as opportunity affords, throughout his life. He will get a better start by using this book in school for two or more consecutive years than by going over all of it in one year.

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For permission to quote extracts from the writings of Oliver Wendell Holmes, Thomas Bailey Aldrich, James Russell Lowell, Henry Wadsworth Longfellow, Edith M. Thomas, Edgar Fawcett, and Christopher Pearse Cranch, expressions of gratitude are due the Houghton Mifflin Company, Boston, authorized publishers of the works of these poets. The stanzas on the Song Sparrow (page 322) by Henry van Dyke are used by permission of Charles Scribner's Sons, New York, publishers of Dr. van Dyke's poems. For the illustration showing Lombardy poplars (page 79), the publishers are under obligations to the William H. Moon Company, Nurserymen, of Morrisville, Pennsylvania.

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PART ONE — TREES

One impulse from a vernal wood
May teach you more of man,
Of moral evil and of good,
Than all the sages can.

WORDSWORTH



Journal of Heredity

FIG. 1. Sycamore tree growing near Webster Springs, West Virginia. The trunk is 9 feet in diameter and about 50 feet high to the fork. The sycamore is one of the largest of our Eastern trees.

TREES, STARS, AND BIRDS

CHAPTER ONE

BECOMING ACQUAINTED WITH TREES

What if another sit beneath the shade
Of the broad elm I planted by the way,—
What if another heed the beacon light
I set upon the rock that wrecked my keel,—
Have I not done my task and served my kind?

OLIVER WENDELL HOLMES

TREES have a fascination for us that abides as long as we live. The coming of the leaves on the bare branches is one of the most pleasing signs of spring; the deep green of the summer foliage is restful to the eyes; the red and gold of the autumn woods is one of the most splendid sights of nature; and even in winter the play of shadows and colors in a woodland is beautiful to behold. In the early history of our country trees were so plentiful that they were destroyed to get them out of the way. Now millions of them are planted every year. We like them about us because they are pleasing to our eyes and afford a source of interest and healthful enjoyment to our minds.

But trees are useful as well as beautiful. They shade us from the summer's sun and help to break the force of the winter winds. Their fruits and seeds are a most important source of food for men and animals, and, above all, they furnish us wood, without which civilized life would not be possible. Much of the material for our houses and vehicles is wood; the paper of the book you are reading is made from wood; your pencil, chair, and desk are mostly wood; and it is probable that in



FIG. 2. A sugar maple in summer.

Jesse E. Hyde

any household fifty different articles could be found that are made wholly or in part from the products of trees. Millions of persons are engaged in making these articles and in procuring and preparing the necessary materials. A knowledge of trees and woods is, therefore, not only satisfying to our minds, but useful in every kind of manual work. Few subjects that we study have more practical value than trees and the woods that come from them.

Studying trees by seeing and thinking. The following pages will help you to become acquainted with some of the trees that are common over large parts of the United States and with others that are especially useful to us. But reading a book about trees is of little use, if you do not observe the trees themselves. Notice the buds, blossoms, and fruit, the shape of the tree and arrangement of its branches, the color of the bark, the



FIG. 3. The same tree in winter.

Jesse E. Hyde

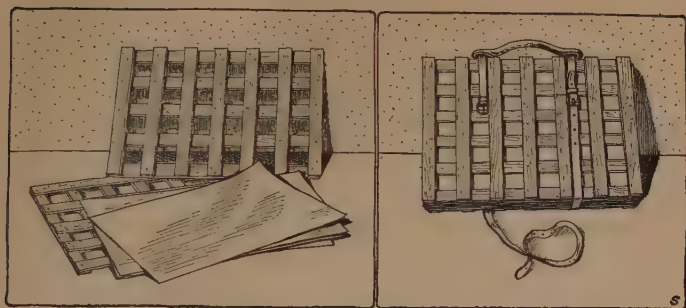
peculiarities of the leaves, and whether any of these parts has a characteristic odor or taste. Try to answer the questions you will find in the various chapters by making the necessary observations yourself or by reflecting on what you have already observed or read. Perhaps some one at home will be interested in discussing these questions with you. If not, do the best you can in answering them alone. When they come up in class, you will learn what others think about them, but knowing this will be of little use to you unless you have thought about them yourself. Other questions as interesting and important as any of those in the book may suggest themselves to your mind. Try to answer these, too, for yourself before asking any one else about them.

How to make a collection. To learn to know the trees, their names, peculiarities, and uses, do not merely

read about them, but look at them and take leaves and other parts to keep for further examination and for comparison with other trees. In gathering leaves for your collection, select those that have not been eaten by insects or damaged in other ways. Unless the leaves are very large, cut off a twig with several typical leaves attached. If you cannot press your specimens at once, you may prevent withering by keeping them inclosed in a box or laying them in a large magazine.

For pressing leaves, use absorbent paper like large sheets of blotting paper, or the soft felt paper that is used under carpets. If you cannot get either of these kinds of paper, place several thicknesses of newspapers between each two specimens. Spread out the leaves on a sheet of the absorbent paper in such a way that each leaf will lie flat and will not cover other leaves. It may be necessary to trim off some of them. Let at least one leaf of each specimen show its under side. Cover the first specimen with absorbent paper and upon this paper spread out another specimen, continuing in this way until you have put into the press all the good specimens you have collected. With each specimen place a strip of paper telling where you found it, the date, and the name of the tree, if you know it. Then put the pile of papers and specimens where it will not be in the way and cover it with a board on which is placed a stone or some other convenient weight. For a few delicate specimens a weight of 15 or 20 pounds will suffice. Ordinarily a heavier weight will be better.

The day after you put the specimens in the press, change the drying sheets. If you use felt paper, one or



FIGS. 4-5. A slat press for drying specimens of leaves and flowers.

two changes at intervals of a day or two will probably suffice for the leaves of most trees. If newspapers are used for "driers," they should be changed each day until the specimens are dry. In pressing delicate plant specimens it is easier to handle them if you lay each one in a folded sheet of thin paper before putting it into the press. You need not remove it from this thin paper when you change the drying sheets, or before you find time to mount the dry specimen.

The slat press. If you have the tools and materials, you can make a slat press, to which pressure is applied by means of a cord or by straps. Such a press is convenient to handle at home and may be carried to the woods. It makes better-looking specimens than a board press, because it is somewhat flexible and applies pressure along the edges as well as in the middle and thus keeps the tips of all the leaves flat.

Mounting specimens. To preserve the pressed specimens so that they can be examined without risk of breaking, mount them on sheets of unruled stiff white paper. You can fasten them to the paper with glue,

but you will find strips of gummed paper or linen more satisfactory for this purpose. These may be purchased from a botanical supply house or possibly at a printing office or stationer's. A neat label may be attached to the sheet. It should give the name of the tree, the place where it grows, the date when the specimen was collected, and the collector's name. Do not mount leaves from more than one kind of tree on the same sheet, as that would interfere with a systematic arrangement of the specimens. If the bark of the tree is peculiar and a thin piece can easily be obtained, attach it to the same sheet as the leaves.

All the sheets of closely related specimens, e.g., the different kinds of maples or oaks, should be placed together in a folder made of a larger sheet of strong manila paper, or a large-paged blank book may be used for mounting the specimens. A bookbinder will prepare suitable books at a small cost for each pupil, if enough of them can be ordered at one time; it is best to have the sheets removable, so as to make possible the insertion of specimens in their proper order. If a suitable book cannot be obtained, a pasteboard box may be used to hold the sheets, or they may be perforated and fastened together in book form by tying them with a shoestring or ribbons.

Fruit collections. The term "fruit" as used in botany means the part of the plant that contains the seed. It may be fleshy or dry, edible or quite unfit for food. From what part of the blossom does it develop? Frequently a tree can be most easily identified by its fruit, and when possible specimens of the fruit should be collected with

the leaves. Fruits that are dry and thin may be attached to the same sheets as the leaves.

Have also a collection of fruits in a box. A strong paper box 3 or 4 inches deep and a foot or so in length may be divided into a score or more of compartments by partitions running both ways. It is best to have the partitions not more than half as high as the box; they are merely to keep the specimens from the same tree together, and apart from those of different trees. Some compartments should be larger than others, to accommodate cones and other large specimens. More than one box may well be used for the fruit collection; or, instead of using a box with partitions, you may sew the fruit specimens to a card or to the inside of a pasteboard box — say a suit box — that can be closed and put away.

Arrangement of specimens. Whatever method is used for keeping the specimens of leaves and fruit in place, they should be arranged according to some plan. Usually they are arranged according to their natural classification. Specimens from different kinds of oak, for instance, will be placed near each other, preceded or followed by beech and chestnut, which belong to the same family as the oak; likewise walnut and the different kinds of hickory will be associated.

School collections. The directions given above refer to individual collections. For use in the schoolroom, large cardboards can be prepared, with specimens of leaves or other parts or products of trees mounted on them. They should be arranged, not with a view to making a design or picture, but to facilitate a comparison of things that are related.

If you wish to preserve for a time the autumnal tints of the foliage, gather leaves that are free from blemishes and ragged edges, and press them for a day or so between blotters. Then dip them in barely melted paraffin and press them between papers with a hot iron. Leaves prepared in this way look very pretty mounted on green cardboard.

Collections of woods. In Europe so few kinds of wood are in common use that woodworkers soon learn to recognize the different kinds. But the number of woods in use in America is so large that even lumbermen, carpenters, and cabinet makers rarely are able to distinguish closely related kinds. They know red oak from white oak, but do not distinguish the various species that are sold under the name of red oak or of white oak.

To learn to recognize a dozen or more kinds of wood is easy. The best way to do this is to get samples from persons who know what they are, label them, and then find articles that are made of these different kinds of wood. Every pupil should have, either at home or in the schoolroom, a collection of this kind, and the school should have a larger collection. The samples can be obtained from various sources, some of which will be suggested by the uses of the wood given for the different species in this book. At a woodworking shop it is often possible to obtain small pieces of a dozen kinds, some of them in sufficient quantity for a class. By visiting more than one such shop quite a variety can be procured without any expense. If the manager is willing to have the whole class visit the factory at one time, much can

be learned. You may send any specimens of wood concerning which you are doubtful to the United States Forest Products Laboratory, Madison, Wisconsin, for identification. A study of Chapter Six and the key beginning on page 147 may help you to identify some common kinds of wood.

Many useful tree products besides wood and fruit are mentioned in the following chapters. A collection of them might be so arranged as to make an instructive exhibit in a schoolroom. Of course there are many trees not mentioned in this book that are just as interesting to those who live where they grow as any that are included here.

References

The United States Forest Service will lend to schools, under certain conditions, a set of samples of sixty-four important woods, with pamphlets, charts, and tables giving information about these woods and the trees that produce them. Lantern slides, photographs, maps, and other material that is most valuable in a study of trees and tree products are also lent, and a number of very helpful bulletins have been prepared. Full information as to the material available for loan or distribution may be secured by writing to The Forester, United States Department of Agriculture, Washington, D. C. A list of books that will prove helpful in studying trees is given on page 156.

CHAPTER TWO

THE STRUCTURE OF A TREE



U. S. Forest Service

FIG. 6. The "Boone Tree" near Jonesboro, Tennessee. On it was carved: "D. Boone cilled A BAR on the tree in year 1760." The tree was blown down in 1916. It was a beech about 90 feet tall.

WE are awed by the grandeur of a great tree; it is the largest and the oldest of living things. Its roots penetrate deep into the earth to anchor the tree in its place and to gather water and food materials from the soil. Its trunk and branches hold the crown of leaves up to the light. It is a living being like ourselves and also a structure that, like a tall building, must carry a great weight and withstand the force of the winds. And so well is this structure planned and built that generations of men and ani-

mals may come and go and even nations may rise and fall while a tree lives on and on. In nearly every part of the United States there are trees still standing that Indian children may have played under before the white man came, and some of the trees that are still growing in the Western states had already

reached a large size before Julius Cæsar or Hannibal was born. One way in which a tree differs from a person is that some of its parts are always young; for unlike ourselves, trees grow as long as they live.

Only part of a living tree alive. The outer bark of an old tree is dead and a great part of the wood is dead. But just as the dead mineral material that is found in the bones of men and animals is useful in supporting them, so the dead wood of a tree forms a skeleton and holds the tree in place; and as the dead outer layers of our skin protect the living tissues beneath, so the dead outer bark of a tree protects the living parts within. The dead parts, of course, do not grow, but they form a skeleton that is useful in supporting and protecting the tree. Each year a new set of leaves, twigs, and small roots are produced, and the part that has changed to wood and died is buried within the tree to aid in its support. You have seen trees with hollow trunks whose crowns remained thrifty. In such trees it is not the living part but the dead wood in the heart that has decayed; but a tree in this condition is more likely to be blown down than one whose trunk is sound throughout.

The living material of a tree. The living parts of a tree, like the living parts of every other plant and animal, are composed of *cells*. In the young growing parts the cells are shaped like little boxes fitted together in an irregular manner. Each cell has a wall about it, and the inside of the cell is composed of living material called *protoplasm*, which in appearance is something like raw white of egg. Besides the protoplasm there is

usually watery sap and often starch or other food material stored in a plant cell, but only the protoplasm is alive.

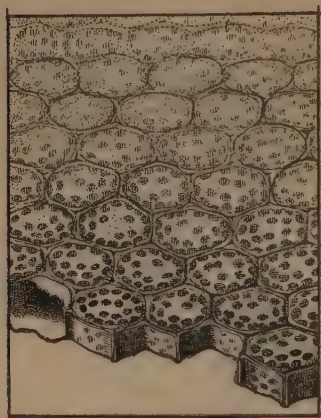


FIG. 7. Cells from a moss leaf.

Although most cells are too small to be seen with the naked eye, the cells in such material as the thin leaf of a moss or the skin from the bulb of an onion may easily be seen with a compound microscope. A tree, therefore, though it appears to be but a single thing, is in reality made of many small parts. A leaf is like a great structure built up of many hundreds of little boxes, and

all the other living parts of a tree are, in the same way, built of many parts.

How the wood is formed in a tree. The cells in the tip of a growing shoot or root of a tree are all alike, but as they grow older great changes take place in many of them. Some of them grow wider and at the same time become greatly elongated. Then the cell walls are thickened by woody material being laid down on the inside of them. Finally, the end walls are absorbed, so that each cell is connected with the one above and below to form a long tube. The living matter in the cells then dies, leaving long, empty vessels, sometimes several inches or even several feet in length, made of cells joined end to end within the plant. These vessels are called *tracheæ* (singular, *trachea*). Through them

water flows up to the leaves. In the cut end of a grape-vine, in the root of a willow, and in many woods these large vessels are plainly visible as open pores. Is it possible to draw air through them?

Others of the cells become changed into *tracheids*. These have thicker walls than the tracheæ, and the end walls are not absorbed. They do not, therefore, form long open vessels in the tree, and the water makes its way from tracheid to tracheid by passing through thin places in the walls. The tracheids

conduct water more slowly than do the much larger tracheæ that have no cross walls, but they give more strength to the wood.

A third element that is prominent in wood, especially in hard woods, is the *wood fibers*. These are formed by groups of cells elongating and forming slender fibers with pointed ends and thick walls. These fibers are much like the tracheids, but they are smaller and have walls so thick that the spaces within them are sometimes almost closed. They do not conduct water, but when the protoplasm in them dies they stand in a tree like bundles of little, tightly sealed tubes filled with air. The function of the wood fibers is to give strength to the wood; their thick walls make it difficult to crush



FIG. 8. Tracheids from a basswood tree (A), and wood fibers from a hard maple (B).

or break them. Oak wood has in it dense bundles of these fibers, and other hard and heavy woods also are richly supplied with them.

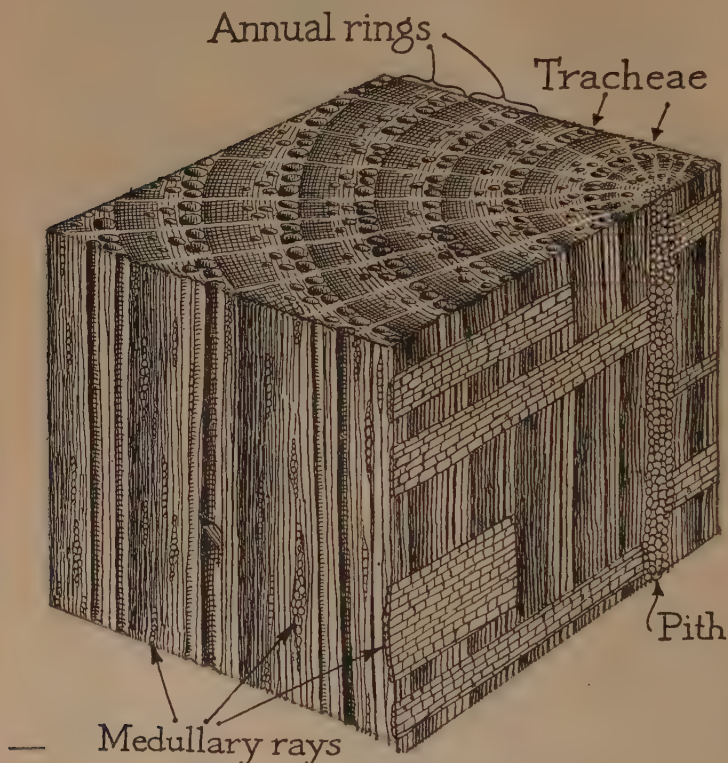


FIG. 9. The structure of wood (diagrammatic).

It should be understood also that in all woods many of the cells do not change into vessels or fibers, but retain their thin walls, and except in the older wood remain alive. They are called *parenchyma* cells. The

pith of a tree is composed of cells of this kind, and in a freshly cut stump or log strands of these cells, called *medullary rays*, or pith rays, may be seen running out from the center to the bark. Cells of this kind may also be scattered through the wood; or they may lie in groups or run in chains, crosswise or up and down, in the wood, making connections with each other and with the living portions of the bark. These living cells are found in the wood of the roots as well as in the trunks and branches of trees. They make up a considerable part of many woods, sometimes as much as a quarter of the whole, and along with the tracheæ are the weakest elements in the wood. If the bark were hewed from a pine, it is estimated that the ends of 15,000 fine rays would be exposed on each square inch of surface. In oaks some of the rays are an inch, and in some species of oak even 4 or 5 inches, in height, and may be seen as light-colored bands running through the wood (page 103); but for each large ray that you see in a piece of oak there are perhaps one hundred too small to be seen without a lens.

These four elements are found arranged in various ways and in different proportions in all our hard woods (page 109). The woods of pines, cedars, firs, and other evergreens are composed of tracheids and parenchyma cells. They lack the large open vessels and the dense bundles of wood fibers and are therefore very even in texture.

How a tree grows in height. In the tip of a tender root or shoot each cell is growing; it increases in size by taking in food and out of this food building up more

protoplasm. After the cell reaches a certain size, a partition is built across it which divides it into two cells. In like manner the two may become four, and so on until a large number of cells have been formed. This multiplication of cells and the increase in size of the cells as they become old cause growth.¹ The trunk of a tree is built upward, and the branches and roots increase in length in this way. New material is built on the top of the trunk, and added to the tips of the branches and roots by the multiplication of the cells in these parts.

Proof of where the trunk lengthens. It is said that if two nails are driven into a living tree trunk, one 6 feet above the other, they will remain 6 feet apart, no matter how long the tree grows. Driving nails into a trunk is not good for the tree or for the saw that may sometime cut it into lumber. Without driving in nails or waiting for years to see the result, you can decide about the lengthening of a trunk by examining trees that have been used as posts for a wire fence. You may find some in which the wire and staples have been covered by years of growth. Are the wires farther apart and higher above the ground than where they were fastened to dead posts? How do you account for the fact that on old trees the distance from the ground to

¹ In older plant cells there is usually in the center of the cell a large amount of water ("cell sap") in which mineral matter and certain food materials are dissolved. The taking in of this water stretches the cell and greatly enlarges it, — sometimes to several hundred times the size it has before the absorbing of the water begins. It is this pumping of water into the young shoots that causes the young branches of trees to push out so rapidly in the spring.

the lowest limbs is so much greater than on young trees? Where is the growth in a tree, that causes the trunk to become longer?

Mark off with ink the first foot of the end of a rapidly growing vine or other shoot into inch spaces. Watch the plant for a number of days. Where do the marks become separated most widely?

How a tree grows in diameter. A tree increases in diameter through the growth of the *cambium*. This is a layer of growing cells just inside the bark. Each year the cells of the cambium multiply; during the growing season they are constantly being divided by longitudinal partitions which cut off layers of cells on both the inside and outside of the cambium. On the outside this forms a thin layer of tissues in the inner part of the bark; inside the cambium a new layer of wood is laid down. Thus each year a sheet of wood is laid upon the tree from the outside. This causes the tree to increase in diameter.

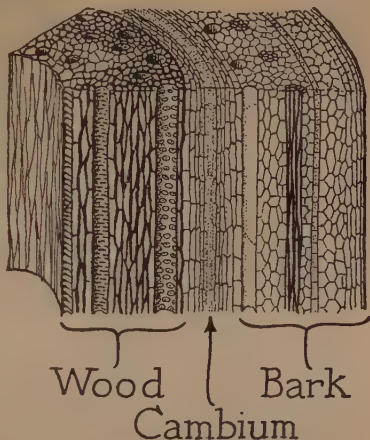


FIG. 10. The cambium is a growing layer between the wood and the bark.

If you could remove from a tree the layer of wood that is added in a single year, what shape would it have? Do the layers of wood that were formed when the tree

was young reach to the top of the tree? Do you understand that if you could begin with the outermost and

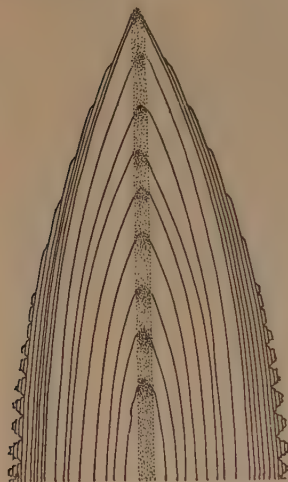


FIG. 11. Diagram showing the structure of a tree. The dotted part in the center represents the pith. The diagram is of course much wider in proportion to its length than is the trunk of a tree.

remove the layers of wood one by one from the trunk of an unbranched tree, you would take off a series of thin-walled hollow columns which taper to a point above and which in the tree fit over one another? The column which grew last year incloses the one that grew the year before, and the columns that will grow in the years to come will be fitted about those that are now standing in place.

Springwood and summerwood. When a pine tree begins its growth in the spring, comparatively large vessels with thin walls are formed. Later in the summer,

as growth becomes slower, the vessels formed are smaller and have thicker walls; the openings in them are much smaller than the openings in the springwood. We have in the tree, therefore, alternating layers of light springwood and of denser summerwood. This causes the appearance of rings in the wood, which you have often seen. In different kinds of trees there are often differences in the springwood and summerwood; these will be discussed in a later chapter (page 43).

The bark of a tree. The inner cells of the bark of a tree are alive, and as the tree increases in size the bark grows by the multiplication of these cells. Thus the bark increases in thickness year by year, unless at the same time the outer layers are scaling off and falling away. Why are the outer layers of bark on an old oak or elm furrowed and broken? Why is the bark of an oak or elm rougher than the bark of a sycamore or birch of the same size?

Cork and how it is formed. In the bark of trees the outer cells become changed into cork. This is done by thickening the cell walls with a waxlike material, after which the protoplasm in the cells dies. The corky layer of cells thus formed protects the tree from drying and also keeps out fungi that would otherwise attack the tree and cause decay. An idea of the great usefulness of the cork may be gained by noting what happens to an Irish potato when the thin, corky layer on its surface is broken or removed. When this is injured, decay very readily sets in, and a peeled potato loses water sixty times as fast as one that has its protective coat. In the cork oak the corky layer is of great thickness and is removed from the tree in large slabs. Examine the stoppers of bottles and see if you can find evidences of annual rings in them. Can you explain why a cork does not become water-soaked as a piece of wood does?

Vessels and fibers in the bark. The inner part of the bark is a layer of tissues consisting of vessels for conducting food, cells in which food is stored, and long, slender, and strong fibers. The latter are called

bast fibers and are very abundant in some trees (page 59). Why do beetles and borers often feed on this layer of tissues in a tree? Will the roots of a tree die if the bark on the trunk is cut all around it? Why?

Telling the age of trees. On the top of a stump or the end of a log you can often count the rings. To determine the age of the tree, do you count the springwood and summerwood as representing two years or one? In exceptional cases, as when a drought divides the growing season into two parts, two fairly distinct rings may form in one year, but generally you can tell the age of a tree quite closely by counting the number of rings. If the section whose rings you are counting was not made near the ground, you must make allowance for the time it took for the tree to attain that height.

Are the annual rings all of equal thickness in the same stump? Are there places where you can count twice as many to the inch as in other places? What may have caused the tree to grow more in some years than in others? Can you think of a way to test the correctness of your explanation? How could you find out, without asking any one to tell you and without reading about it, whether a certain kind of tree grows fast or slowly? On the stump or other section of a tree or of a branch, is the same ring uniform in thickness all the way round? How do you account for this? Frequently disputes about the ownership of land have been decided by the age of trees and by counting the rings to find how many years ago a certain mark was placed on a tree by a surveyor.

You will find it interesting to fix as nearly as possible

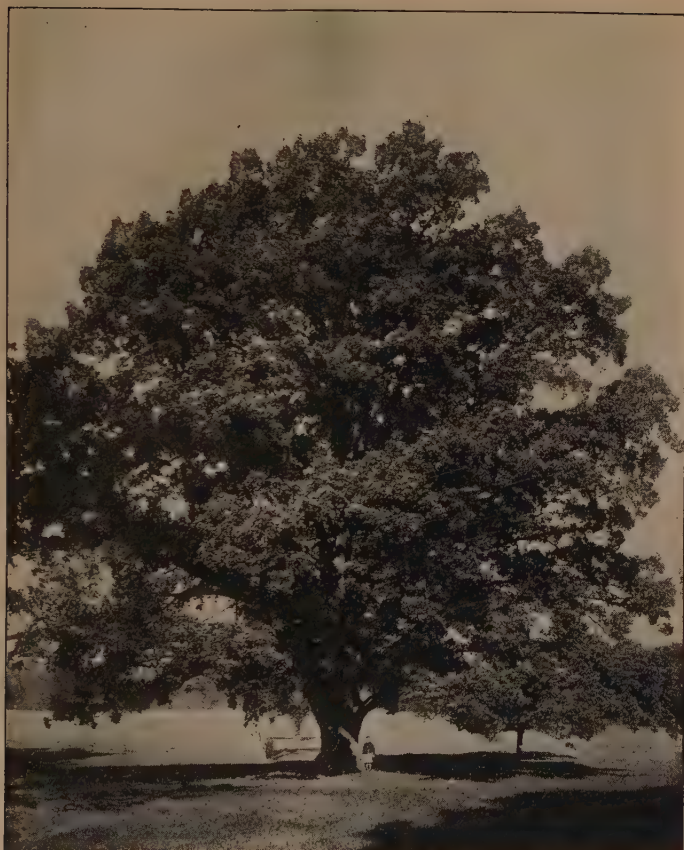
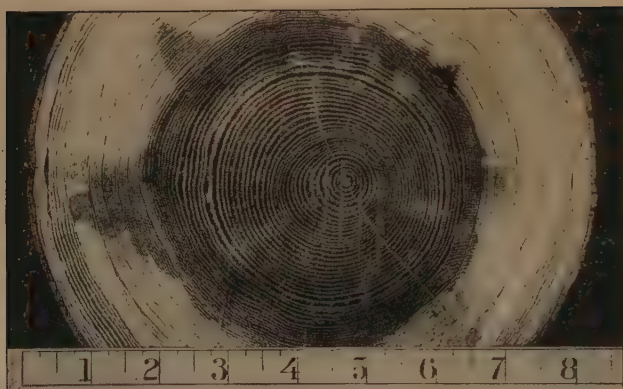


FIG. 12. The monarch oak, the patriarch of the trees,
Shoots rising up, and spreads by slow degrees.
Three centuries he grows, and there he stays
Supreme in state; and in three more decays.

DRYDEN

the date when some large tree first began to grow. If you are careful, you will probably come near the actual date. Having done this, try to form a mental picture



U. S. Forest Service

FIG. 13. Section through a white ash almost 100 years old. It grew in a thick forest, but 12 years before it was cut some of the trees about it were blown down by a severe storm. Study the rings and see what you can learn of the life of the tree from them. (See also Figure 61, page 99, and Figure 87, page 131.)

or give a description of the surrounding country when this tree was a young sapling. Regarding the tree as an individual which has suffered and enjoyed many experiences, you might write a story of its life, an imaginary autobiography, telling what it has seen and done.

CHAPTER THREE

MAPLES

October turned my maple's leaves to gold;
The most are gone now; here and there one lingers:
Soon these will slip from out the twigs' weak hold,
Like coins between a dying miser's fingers.

THOMAS BAILEY ALDRICH

MAPLE trees may be found in most parts of the United States and southern Canada. The larger kinds are widely planted for shade, and smaller varieties with cut leaves or richly colored foliage are often used for ornamental purposes in parks and on lawns. Some maples produce wood that is hard and handsome, and the leaves of many kinds show beautiful autumn coloration.

The blossoms of the maple are small, but they abound in honey and are very attractive to bees. In spring or early summer the peculiar key fruit is produced (Fig. 17). Among children, who like to eat them, these are known as "chickens." At the base of each wing is a seed. Have you ever noticed it? Are the leaves on one branch sometimes more highly colored than those on the rest of the tree? Will this branch show the same peculiarity year after year?

Making maple sugar. You have eaten maple sugar or maple sirup. It is made usually from sap of the sugar maple, occasionally from that of other maples. Good sugar may be obtained also from hickory or birch sap.

The first warm days in February or March start the sap flowing. Then the tree is tapped — that is, a hole is bored through the bark into the wood — and a spile, or little spout, is inserted so that the sap will flow along

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FIG. 14. Tapping the tree.

it and be caught in a bucket instead of trickling down the trunk of the tree. The rise of the sap in early spring is due partly to freezing and thawing; therefore a succession of warm days and cold nights is necessary for a continuous flow. Later in the spring the sap becomes watery and bitter and is not suitable for sugar making. From 25 to 50 pounds of maple sap must be boiled down to obtain 1 pound of sugar.

A group, or orchard, of sugar maples is called a "sugar bush." The place where the sugar is made is called a "sugar camp." Oftentimes one or more sheds are built in the woods to accommodate those who gather the sap and keep up the fires under the kettle or great pans that are used in evaporating the water from the sap. Boys enjoy the work of sugar making and often



FIG. 15. Collecting the sap.

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stay in the camps at night. Nevertheless, much labor is required to produce a gallon of sirup or a few pounds of sugar. Can you think of three reasons why genuine maple sugar is expensive?

The maple-sugar industry has become so important in some of the Northern states and Canada that those who engage in it make use of improved evaporators. These are broad, shallow pans with a number of partitions that do not reach entirely across the pan. The openings left between these partitions and the sides of the pan alternate, so that the sap in flowing around the partitions goes from one side of the evaporator to the other. As water is continually being driven off by the fire under the pan, what was at first thin sap has become thick sirup by the time it reaches the farther end of the

evaporator. This sirup may be converted into sugar by driving off still more water. To test the boiled sap, a small amount is stirred and cooled in a saucer. If it granulates and adheres to the spoon and saucer, evaporation has gone on long enough, and the hot sirup is poured into molds to form cakes of sugar of the desired shape.

Maple sugar, like that made from sugar cane, is darker than ordinary brown sugar, unless the impurities are removed. To do this milk or beaten eggs are stirred into the boiling maple sap. This causes most of the coloring matter to rise to the top and mingle with the froth, which is then skimmed off. Those who live near sugar bushes enjoy making and eating maple wax. This is formed by letting the hot sirup fall upon snow or ice.

The sugar made by the leaves of the trees. The leaves are the food-making organs of a plant, and the sugar that is obtained from maple sap in the spring was made the summer before by the leaves of the tree. As the sugar is manufactured it passes down from the leaves into the trunk and roots of the tree, and is stored in the living cells of these parts in the form of starch. Then when food is needed in the spring to enable the buds to grow and expand into blossoms and leaves, and to produce the seeds, the starch is changed back to sugar, which is dissolved out of the storage cells and carried upward in the sap.

1 The sugar that is manufactured by the leaves is made from water, which is absorbed by the roots and passed up through the vessels of the wood, and from carbon



FIG. 16. Silver maples in winter.

R. E. Horsey

dioxid, a gas that is taken in from the air. In the leaves these are united to form sugar. Leaves cannot do this work without light; when the sun shines on them it supplies the energy for the process.

Uses of the wood of the maple. The sugar maple is called also "hard maple." Try to cut a piece across the grain with a knife or saw and see whether it is the hardest wood you have. Hardwood floors are often made of maple, the pieces of which have been planed and matched with tongue and groove. Maple wood is used for this purpose because it has no soft places to wear away and leave the floor uneven or splintered (page 152).

"Bird's-eye maple" is an ornamental wood obtained from certain sugar-maple trees of the same species as those whose wood is straight-grained. "Curly maple" is found in this species as well as in the soft maples.



FIG. 17. Leaves and fruit of silver maple (A) and red maple (B).

Until a tree is cut it is seldom possible to tell whether its wood will show these peculiarities.

Have you seen maple furniture? Try to find examples of bird's-eye maple and of curly maple. Tool handles, rulers, butcher's blocks, piano actions, and the backs and sides of violins often are made of hard maple. This wood is used also for shoe lasts and pegs, croquet balls and mallets, for various implements, and in the construction of machinery, cars, and automobiles. It has a fine and even grain, polishes well, and is heavy, hard, strong, and elastic. Which of these properties are most needed in a wood used for each of the purposes mentioned?

The sugar maple as a shade tree. The sugar maple is one of the very best of our shade trees. It is well shaped, affords dense shade in summer, and in autumn becomes beautiful because of the rich and varied colors of its foliage. In the spring its blossoms unfold with the leaves. It grows more slowly than the soft maples, but it requires less moisture and is more useful and durable.

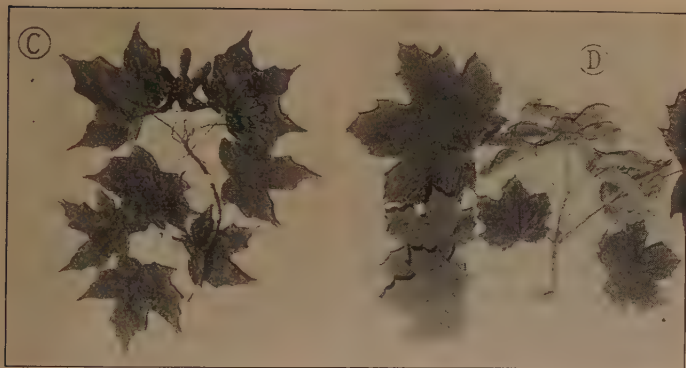


FIG. 18. Leaves and fruit of sugar maple (C) and Norway maple (D).

Red and silver maples. The red maple and silver maple are both soft maples. They are extensively planted for shade, but like the sugar maple they grow wild also in all our Eastern states, and in southeastern Canada, and as far west as Kansas. You will not find it easy to distinguish these maples at all times from each other or from other maples. In autumn the leaves of the red maple turn crimson, and where this species abounds it adds much to the beauty of the woods at that season. Its blossoms, which are red, open before the leaves.

The silver maple, also called "white maple," grows larger than the red maple. It is one of the most common of shade trees, although not always known by its correct name. The leaves are pale underneath, but not so white as those of the white poplar. Its blossoms open in advance of its leaves, before most kinds of trees show signs of life.

Experience has shown that the silver maple, in spite

of its rapid growth, is a poor tree for street planting. Many kinds of insects eat the foliage or bore into the trunk. The breaking of its limbs causes much trouble. In the living tree the wood is quite subject to decay. When the tree is cut down, even the wood that is still sound is not very valuable, but both silver maple and red maple are now used for woodenware and flooring.

The Norway maple. Of late years the Norway maple has been planted in many cities in the United States. Its flowers are greenish yellow; its leaves are large and remain green until late in autumn. The leafstalks contain a milky juice. This tree is remarkably free from insects and has proved a very satisfactory shade tree.

✓ **Maple leaves and their arrangement.** Notice that the leaves of different kinds of maples differ a little in shape. All have, however, the main veins diverging from the leafstalk, whereas elm leaves have a midrib with veins coming off on each side (page 38). The former arrangement is called *palmate* (palmlike); the latter is *pinnate* (featherlike). Find other examples of palmate and of pinnate leaves. Which is wider in comparison with its length, a palmate or a pinnate leaf?

The maples have the leaves and twigs *opposite* each other on the stem, as contrasted with the *alternate* leaves and twigs of the elm (Fig. 23). Find other examples of opposite and alternate leaves.

The ash-leaved maple. This tree, more commonly called the "box elder," is a maple, as its fruit shows. It differs from the other maples, however, in having *compound* instead of *simple* leaves; that is, its leaves are cut into a number of leaflets instead of being all in

one piece. In ordinary locations it is not so desirable a shade tree as some of the other maples, but it grows rapidly and may be planted in sandy or gravelly soil, where most other trees do not thrive. The box elder is distinguished from other trees with opposite leaves by the green bark of the young shoots. This tree is rare east of the Appalachians, but can be found in most parts of the United States with



FIG. 19. Leaves and fruit of the ash-leaved maple or "box elder." This maple, unlike the other members of the family, has compound leaves.

the exception of the states in the northwestern portion.

The maple family. Nearly one hundred species of maples are known in the wild state, most of them growing in the north temperate zone. Some are found on mountains, others on ground that is low and wet. Most species thrive best in rich, moist soil. They differ greatly in size; some of the Japanese species, which are cultivated in this country on account of the rich colors of the finely divided foliage, seem like dwarfs when compared with our great sugar maples, which tower to a height of 100 feet.

Considering their wide distribution, the great number

that have been planted, and the variety of uses made of them, we may well give maples a prominent place among important trees.

Maple seeds dispersed by the wind. Out of doors, when the wind is blowing, drop a maple seed from a height of several yards and see whether it falls straight down. Does it acquire a whirling motion? Does this retard its descent? Is it better for the seeds of a maple to fall close to the tree or to be carried to distant places? Why? Are seeds more likely to get loose from the tree on still days or windy days? How far do you suppose the wind carries them? Name different kinds of trees with winged fruits; name some kinds whose seeds have cottonlike appendages that enable them to be carried through the air. Have you seen young maples pushing up in lawns or along fences?

Leaves and light. Examine Figure 18. The stalk of one leaf has lengthened and pushed the leaf out to the light, past the other leaves on the tip of the branch. Almost any maple tree will show this interesting leaf arrangement on dozens of its twigs.

Study the plants that are growing about you and note that leaves always seek the light. When a vine grows on a wall, each leaf fits itself into its space as best it can to receive the light. Note the arrangement of the leaves on a plantain or a dandelion. Do the upper leaves grow so that they will not cover the lower ones, or must the lower leaves take care of themselves? Does each leaf on a tree grow as it pleases, or is there some outside directing force that causes each one to take its proper place?

CHAPTER FOUR

BIRCHES

The birch, most shy and ladylike of trees.

LOWELL

BECAUSE of their grace and beauty birches are a favorite subject for landscape artists and photographers, and they are frequently planted in parks and on lawns. The white and the paper birch are the species of birch most frequently planted for ornamental purposes. They are especially effective when placed among evergreens, because of the contrast in colors. Many of the white birches have slender,



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FIG. 20. White birches.

drooping branchlets with deeply cut leaves that might be taken for those of some varieties of maples. White birch grows wild in Europe and Canada and to some extent in our Northern states, but with us the paper birch is more common. Where a forest of spruce or of certain species of pine — as white pine — has been burned, paper birch and aspens spring up. In the abundant sunlight of the open spaces these trees



U. S. Forest Service

FIG. 21. River birches.

grow more rapidly than seedlings of the spruce or pine, and a forest of birch and aspen grows up in place of the ever-green forest.

Birch bark. The yellow birch has yellowish or silver-gray bark which has an aromatic odor. The bark of the white birch and paper birch is creamy or pinkish white and splits into paperlike layers. From birch

bark the Indians made canoes, as well as boxes, buckets, baskets, kettles, and dishes. In making their canoes, they stitched together large plates of birch bark with the fibrous roots of white spruce, coating the seams with resin obtained from spruce and pine trees. If you can get a piece of the bark, see into how many layers you can split it.

In parts of northern Europe the bark of the white birch is used for shingles. Boats made from it are used on the Volga River. From it are made birch oil and birch tar. Russia leather has an aromatic odor due to the oil of birch bark used in tanning it. As the odor repels insects, this leather is valuable for binding books. A few such bindings in a bookcase are a safeguard against insect enemies, and this

oil is said also to prevent damage to the books by mildew.

Birch wood. The wood of the white birch is used as a fuel for smoking hams and herrings, because of the flavor which it imparts. Being light colored, soft, and easily worked, it is used for making spoons, ladles, bowls, and fish casks. Spools, wooden shoes, ox yokes, chairs, and tables also are made of it. Charcoal made from it is burned in forges, and soot made from birch fires is used for making printer's ink.

The wood of the paper birch is used for fuel, shoe pegs, spools, and toys. The yellow birch and sweet birch yield wood that makes fine furniture and a good interior finish for houses. It is often stained dark red and varnished. It is then said to have a "mahogany finish." Few trees are useful for so many purposes as is the birch.

Birches in the far north. The paper birch grows in Newfoundland, in Labrador, about Great Slave Lake, and along the valley of the Yukon. Dwarf birches, which are mere shrubs, grow even farther north. They are common in Greenland and in the arctic barrens of America and Asia, beyond the northern limit of trees. In these frigid regions the birches have for companions several kinds of willows, only a few inches tall, crowberry, bearberry, and a number of other low shrubs, besides lichens, mosses, and, during the short summer season, many herbs with brightly colored blossoms.

Size of branches and size of leaves. Have you ever thought of any connection between the size of a tree's leaves and the coarseness or slenderness of its branches?

Even in winter birch trees look quite different from ash or hickory, not merely in color but in the appearance of the branchlets. Can you explain the difference? Name several trees with slender branchlets and others with thick branchlets.

The function of the branches is to hold the leaves up to the light, and the number of branches required depends on the size of the leaves. Trees with small leaves, like birch, elm, and willow, have very numerous branchlets. Those with large leaves, like ash and hickory, do not require so many branchlets. The leaves themselves reach out to the light and fill up the spaces in the crown of the tree. Most palm trees, of which there are a thousand kinds in the tropics, do not branch at all, but they have immense leaves with long stalks to reach out to the light.

Breathing pores in the bark of small branches. On the twigs or small branches of a tree look for small oblong and elevated places on the bark. These are called *lenticels*. They are breathing pores through which the air can enter to reach the living inner portion of the bark and from which water vapor escapes. On birch and cherry trees the lenticels may be seen not only on the branches but even on the trunk. Here they have become elongated by the growth of the bark. Does their long axis extend across the tree, or up and down?

Lenticels are to be found on all trees. Where the bark is very thick, as it is on old oaks, they are at the bottom of the deep cracks.

CHAPTER FIVE

ELMS



Journal of Heredity

FIG. 22. Elm at Northampton, Massachusetts. It is 75 feet high, 18 feet in circumference, and has a spread of 125 feet.

IN the wild state elms are common throughout most of the country. In many cities they are planted for shade more generally than any other kind of tree, for in deep soil they grow fast and make large, well-shaped trees. The elm is one of the first trees to show signs of life in the spring, and at this season it has a peculiarly graceful and airy appearance. The flowers do not attract much attention, although they appear before the leaves. The winged fruits soon develop and are blown away by the wind, some falling where the seed may grow into another great tree.

The American elm. Without the flowers or fruit, or even the leaves, an American elm may be distinguished



American Forestry

FIG. 23. Leaves, flowers, and fruits of American elm.

from other trees. Its bark is dark and rough, with deep fissures. The trunk is short and divides into large branches before reaching the upper parts of the tree. The small branches or twigs are slender and the outer ones drooping, giving it a graceful appearance by which you can tell it at a considerable distance even in winter.

In the woods the American elm sometimes grows to be more than 100 feet tall, and in open places a large tree spreads over a wide area. There have been well-known trees of this kind in the older cities of the Eastern

states, such as the famous elm at Cambridge, Massachusetts, under which Washington took command of the Continental army, and the one at Philadelphia, under which William Penn signed a treaty with the Indians.

Notice the buttresses that are found at the bases of many large elms. What purpose do these serve, and why are they especially needed by the elm?

The wood of the elm. Elm wood is less prized than many other kinds of wood. It is heavy and solid, but difficult to work because it is very hard to split. This is because, as the wood fibers grow, the ends push past each other and become interlaced. Because of its toughness, however, elm wood is useful for some purposes. The hubs of wheels and the handles and bands of baskets are made of it, and much elm is used for barrel hoops and crating.

Elm trees are subject to decay, and many of the old elms that were formerly so common in the woods contained large hollows high up in the trunk, or even in the limbs. These afforded nesting places for owls and homes for raccoons, porcupines, and squirrels. Many of the "bee trees," which were cut down simply to get the stores of honey the bees had placed in them, were elms.

The early settlers chopped down elms for still another purpose. Knowing that the buds and twigs are nutritious, they gave their cattle a chance to eat them, when other feed was scarce. The cattle would leave their barn feed to browse on the elm.

The slippery elm. The red elm, or slippery elm, has

a fragrant and mucilaginous inner bark which children like to chew. Its leaves are larger and rougher than those of the American elm, and its wood, in contrast with that of the latter, is easy to split. Because it wears well and is pliable when steamed, it is sometimes used for making sleigh runners. It is also used for parts of agricultural implements. It is sometimes used locally for the framing of buildings. The slippery elm grows in deep, fertile soil on the banks of streams and on rich, rocky hillsides, throughout most of the eastern half of the United States.

Objections to elms as shade trees. The principal objection to the elm for planting is that its foliage is attacked by many kinds of insects. Caterpillars of the gypsy moth and tussock moth as well as the larvæ of the elm-leaf beetle eat the leaves. In the streets of Eastern cities many elms have been ruined by insects. On this account it would be better not to plant so many elms. They should not be planted at all along ordinary city streets where houses are close to the sidewalk, for they need space to grow into their full beauty. Nor should they be planted where large quantities of soft coal are burned, for their rough leaves catch the soot, which, sticking fast, chokes up the breathing pores and in time kills the tree.

What beautiful bird selects the swaying branches of the elm from which to hang its nest? Why is the nest built so far out from the trunk of the tree?

Shapes of trees. The trunks of some kinds of trees divide into so many branches that in the upper part of the tree no trunk can be distinguished. Such trees

are called *deliquescent*. In other kinds of trees the trunk extends to the top of the tree. These trees are called *excurrent*. The pine (page 129) is an example of a tree of this kind.

Examine an elm tree. Is it of the *deliquescent* or *excurrent* type? Note that the lower branches are drooping, those midway up the tree are horizontal, and those in the top of the tree ascending. By this arrangement all the leaves are exposed to the light.

Position of leaves in the crown of a tree. If you stand under a young Norway maple or other tree that has a dense head of foliage, and look up, you may be surprised to see how scanty the foliage is except near the outside of the head. Such trees have a dense layer of leaves on the outer branches, and these cut off the light from the bases of the branches so that few or no leaves are found in the inner part of the crown. Other kinds of trees have open crowns; the outer branches stand apart so that the sunlight penetrates to the heart of the crown. Such trees have leaves near the trunk and on twigs springing from the bases of the large branches. To which of these types of trees does the elm belong?



FIG. 24. American elm near Mumford, New York.

CHAPTER SIX

WOODS AND THEIR PROPERTIES

So the Deacon inquired of the village folk
Where he could find the strongest oak,
That couldn't be split nor bent nor broke, —
That was for spokes and floor and sills;
He sent for lancewood to make the thills;
The crossbars were ash, from the straightest trees,
The panels of whitewood, that cuts like cheese,
But lasts like iron for things like these.
The hubs of logs from the "Settler's Ellum," —
Last of its timber, — they couldn't sell 'em.
Never an ax had seen their chips,
And the wedges flew from between their lips,
Their blunt ends frizzled like celery tips;

* * * * *

That was the way he "put her through."
"There!" said the Deacon, "naow she'll dew!"

OLIVER WENDELL HOLMES

DIFFERENT kinds of woods differ greatly from each other, and each kind is better fitted for some purposes than for others. Workers in wood are well aware of these facts, and constantly try to select the kind of wood best suited to the work which they have in hand. The Deacon made his "one-hoss shay" last for a hundred years, by using exactly the right kind of wood in each part. Why does one wood differ from another, and what are the important differences that are found in woods of different kinds?

Properties in which woods differ. Woods differ in heaviness, hardness, and strength; in stiffness; in elasticity and brittleness; in cleavability, or the ease with which they can be split; in the amounts they shrink when dried and in their liability to warp; in straightness of grain; in evenness of texture; in durability;



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FIG. 25. Chestnut wood photographed through a microscope. Chestnut is a ring-porous wood; that is, the large pores are collected in the springwood.



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FIG. 26. Wood of the black cherry as seen under the microscope. It is diffuse-porous; that is, the large pores are scattered through both the spring and summer wood.

and in many other ways. Since the properties of a wood depend in great part upon its structure, it is well to understand how the different elements of which wood is composed are arranged in some common woods of different kinds.

Three classes of woods. In oak, elm, hickory, and ash, large tracheæ (page 12) are especially numerous in the wood formed in spring, and the cut-off ends of



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FIG. 27. Cypress wood as it appears under the microscope. The annual rings in woods like cypress, pine, and cedar are very noticeable, but there are no large open pores and they are classed as non-porous woods.¹

these vessels are visible as open pores in the ends of a piece of one of these woods. The summerwood of these trees has fewer tracheæ than the springwood, and they are of smaller size. Such woods are called *ring-porous*; in them the large tracheæ are arranged chiefly in rings in the springwood.

Maple, birch, and basswood are *diffuse-porous*; that is, the vessels are scattered through both the springwood and summerwood. Is it easier to count the rings in ring-porous wood or diffuse-porous wood? Why? Diffuse-porous woods are of more

even texture than the ring-porous kinds. What diffuse-porous wood that we have studied is extensively used for flooring?

Pines and other conifers have no tracheæ and their woods are classed as *non-porous* (page 109). Yet annual rings may be clearly seen in a piece of pine. The summer tracheids are narrower and thicker walled, making

¹ All the photographs of microscopic sections of woods shown in this book are magnified 10 diameters.

the summerwood denser than the wood formed in the spring.

Name kinds of wood in which the annual rings are very noticeable ; other kinds in which they are not easily seen.

Heartwood and sapwood. In a young tree the water is conducted up to the leaves through the tracheæ and tracheids of the wood. As the tree grows older and larger, the newer branches and leaves form their connections with the outside layers of the wood and gradually the vessels in the heart of the tree cease to carry water. Often they become filled with resin, gum, coloring materials, or even mineral matter. In a large tree, therefore, only a circle of wood around the outside is carrying water ; by far the greater part of the wood is of no use to the tree except to support it. The pith and the cells of the medullary rays also die in the old wood, so that even in a sound tree of large size it is only the outer part that contains cells that are alive.

In a tree the wood that is no longer conducting water is called *heartwood*. That which carries water is called



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FIG. 28. Wood cut from white birch trees, showing heartwood and sapwood.

the *sapwood*. In black walnut, red cedar, and many other trees, coloring matter deposited in the heartwood makes it darker than the sapwood. The contrast in most species is not so marked as in black walnut; in fir, spruce, and buckeye, the heartwood and sapwood look much alike. In black locust, hardy catalpa, black cherry, and several other species, the thickness of the sapwood of old trees is usually less than an inch; in the hickory, elm, beech, and many other species, it is several inches. In many species the dark-colored heartwood is more valuable for furniture or interior finish than sapwood from the same tree.

Other differences in wood structure. One important difference in different kinds of woods is in their medullary or pith rays. These consist of thin-walled, brick-shaped cells, whose principal function is to store nourishment for future use. Some of the rays extend all the way from the bark to the pith, while others which started later do not reach all the way to the pith. They are thin sheets of tissue that may be thought of as being shaped like a ruler set on edge. When viewed from the side they may, in woods like white oak, have a width of an inch or even 4 or 5 inches. When their edges are looked at, as in the end of a log or board, they are lines.

In oak, beech, sycamore, maple, and cherry, the larger pith rays are easy to see; in many kinds of wood they are so small that they can hardly be seen without a lens; in some species they are quite invisible unless considerably magnified. Just how would you split a section of a tree trunk to split it along the pith rays? Is it easier to split wood along these rays or across them?

Woods differ also in their grain; some are straight grained, in others the fibers are interlaced. Which ones are easier to split? Name some kinds of wood that are hard to split, and others that are easy. Is there much difference in the cleavability of pieces from the same species of tree? Some woods can be split very easily along the lines between the annual rings.

In yellow pine the summerwood is much harder than the springwood, as you will see if you push the point of a pin or a knife blade into it. Is the summerwood lighter or darker than the springwood? Can you see any objection to using yellow pine for lead pencils, instead of a wood of more even texture?

Density of wood. The hardness and strength of a wood depend on the amount of cell-wall substance in it, which varies with the weight of the dry wood. Foresters and builders are therefore much interested in the densities of different woods; for if they know the density, they can judge to some extent whether or not a wood will be valuable for certain purposes. They know that if it is heavy, it contains many thick-walled fibers and will prove to be hard and strong. If it is light, the walls of the fibers are thin, and it will, therefore, lack hardness and strength.

Finding the density of wood. If a piece of wood floats with half its volume out of water, it does so because it is half as dense as water. *Arbor vitæ* is so light that it will float with two thirds of its bulk above water. A cubic foot of it weighs only one third as much as a cubic foot of water, or a block of *arbor vitæ* of any size weighs only one third as much as an equal

volume of water. This is equivalent to saying that its density is one third that of water. Densities are usually expressed by decimals. Thus the density of arbor vitæ is .325. Is that more or less than one third?

Place in water various kinds of seasoned wood and notice their relative densities. Slender pieces may be floated in a jar that is narrow enough to keep them upright; other pieces can be laid flat on the water. When the piece has come to rest, measure carefully the distance between the lower end of the piece of wood and the upper surface of the water. Compare this with the whole height or thickness of the piece. If three fourths of the wood is under water, it has a density of $\frac{3}{4}$ or .75. In determining density in this way, does it matter if the piece of wood is not regular in form? How could you prevent water from soaking into the wood during the experiment?

Some kinds of wood are so much lighter than others that you can judge of their relative density by merely picking up pieces of them and noticing their size and weight. Try this with two pieces of nearly the same density; then determine the density of each piece by the method given above.

With a knife test the hardness of several kinds of wood. Are the harder ones always the denser ones? Make a list of several kinds of wood that are valued for fuel. Are they valued because they burn fast or long? Are they as dense as those of less value for fuel?

Why water-logged wood sinks. The material of which wood is composed is heavier than water, and a piece of wood floats only because of the air spaces it

contains. When a piece of wood is left in water for a long time, the water gradually finds its way into the vessels and fibers, driving out the air. Then the wood becomes "water-logged" and sinks. In green wood the vessels of the sapwood are filled with water, and a piece of green oak will sink in water. Some dense tropical woods will sink even when well seasoned, but all the timber produced in the United States north of Florida will float after it has been dried. Have you in your collection of woods any kinds that will sink in water?

Shrinking, warping, and checking of woods. As wood dries, it shrinks. A board 10 inches wide sawed from a recently felled cottonwood tree will lose half an inch of its width after drying in the open air. In soft pine, spruce, cedar, and cypress, the shrinkage is hardly one third of an inch in a 10-inch board; in hickory and young red oak it amounts to nearly 1 inch in 10. When dried in a kiln, wood loses more water and shrinks still more than air-dried wood. If furniture were made of green boards fitted together, what effect would the drying have? In general, the heavier a wood is the more it shrinks when dried.

Swelling is the reverse of shrinking. It is due to thickening of the walls of the wood fibers and vessels by absorption of water. This causes a board to become wider and thicker. You have noticed the effect of this on doors. If a door fits closely all around when it is dry, it may stick at the top or bottom or at the sides in damp weather.

Checking is the forming of cracks in a piece of timber, due largely to shrinking and swelling of the wood.

This weakens the timber and lessens its value. Do you think thick or thin pieces are more likely to check? Pieces dried in the sun or in the shade?

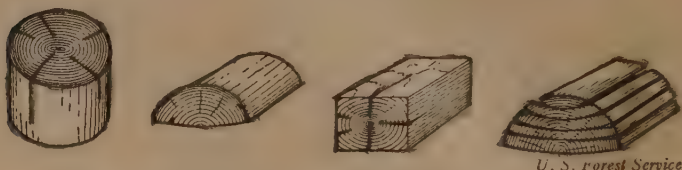


FIG. 29. Checking and warping due to shrinking of wood when dried.

Warping is due to greater expansion or contraction of the wood at one surface of a board than at the other. A board lying on the damp ground absorbs water from beneath, and the wood fibers of the lower part of the board swell so that its width becomes greater on the under surface than above. This causes the board to warp. Which side becomes convex? What would be the effect of turning the board over? Make the above experiment with a thin piece of board laid on damp earth. Some kinds of woods warp more than others. Cottonwood boards have a special tendency to warp, and a board of this kind would be a good one with which to experiment.

A board changes its length very little when it shrinks or swells, and it shrinks or swells much less in the direction across the annual rings than parallel with them. Will a door swell more sidewise if all the boards run the long way of the door or if some of them run crosswise?

CHAPTER SEVEN

THE ASH

THE ash belongs to the olive family. It is common in the wild state and is often planted for shade; yet many persons fail to recognize ash trees when they see them. The leaves of the ash are large and compound and bear some resemblance to the leaves of the walnut and hickory, but the leaves of these latter trees are arranged alternately on the branchlets, while



FIG. 30. Leaves and fruit of the white ash.

those of the ash are opposite. Since young branches come from buds at the bases of leaves, the branches of the ash are also opposite, while those of the walnut and hickory are alternate. The fruit of the ash is winged and identifies the tree at once (Fig. 30).

To support the long and heavy leaves of the ash the branchlets must be large and strong. This gives to the ash in winter a stiff and naked appearance, very different from the graceful elm with its many slender, drooping twigs. The bark on the branches of most kinds of ash is somewhat tinged with red.

Species of ash. Black ash may be distinguished from other native species by its *sessile* leaflets; that is, each leaflet is attached to the common leafstalk without even a short stalk of its own. Blue ash may be recognized by its square branchlets. The branchlets and leafstalks of red ash are downy, those of the white ash smooth. Where only these four kinds grow, they can be distinguished in this way; but four other kinds grow in the eastern half of the United States, and several others

farther west. The following points may prove helpful in recognizing the different kinds:

The inner bark of the blue ash will give a blue color to water. The bark on the branches of the red ash has a more decidedly reddish brown color than the bark of other species. Black ash has very dark-colored buds. White-ash leaves are usually whitish underneath. Green-ash leaves are brighter green than the leaves of other species. Pumpkin ash, which grows in the



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FIG. 31. Ash trees in a North Carolina forest.

South, often has the base of the trunk bulging so that it is of a much greater diameter at a height of 4 feet than at a height of 12 feet. Water ash grows in Southern swamps. The Biltmore ash is found from Pennsylvania to Georgia, but was first distinguished from other kinds of ash at Biltmore, North Carolina.

The best kinds of ash for planting. The European ash is an attractive shade tree. A tree of this kind was set out in Sandusky, Ohio, after the Civil War, where a quarry had been filled with earth. It now spreads

about 80 feet and is the finest tree in the city. How did its location favor its rapid growth?

White ash also is a desirable tree for planting, though it does not give so dense a shade as some other trees. It grows fast, is straight and symmetrical, and has no serious insect enemies. Blue ash, which is much less



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FIG. 32. A white ash that grew in a forest. The other trees have only recently been cut away from around it.



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FIG. 33. A white ash that grew in the open. Note the difference in the trunk of this tree and that of the tree shown in Figure 32.

common, also is recommended for planting, but it is more likely to be damaged by insects.

Properties and uses of ash wood. Since ash is strong, elastic, and not very heavy, it is a valuable wood for oars, bats, handles of hoes, rakes, and pitchforks, and for various parts of wagons, railway-car frames, and agricultural implements. White ash and blue ash produce the best timber, when a

high degree of strength and elasticity is required. By the elasticity of a wood is meant its power to spring back after it has been bent.

For ball bats and some other purposes second-growth trees are valued much more than those which formed part of the original forest. Which do you think grew faster? Contrary to what you might think, the more rapidly growing trees produce the tougher wood. This is because the wood is ring-porous, and the faster the tree grows the thicker the layers of firm summerwood will be and the farther apart the rings of weak, porous springwood will be placed.

The mountain ash. The foliage of the mountain



American Museum of Natural History

FIG. 34. The mountain ash
Decked with autumnal berries that outshine spring's
richest blossoms,
Yields a splendid show amid the leafy woods.

WORDSWORTH

ash somewhat resembles that of the true ash; but, as is shown by the flowers and fruit, it belongs to the family of the rose and apple and is not a relative of the ash. The streets of Toronto, Canada, are beautified

by these trees, and they should be planted more frequently in the United States. They are found growing wild only where the climate is cool. Their scarlet fruits, which attract birds, make them ornamental all winter, and their foliage is admired in summer. The mountain ash has one serious disadvantage: it suffers much from the scale insects which attack members of the apple family.

Growth affected by light. Have you observed how a plant, when placed in a window, grows toward the source of light? Notice trees that are growing in open places, along streams, in the edge of a forest, and in a forest surrounded by other trees. Do the branches grow in such a way as to bring the leaves to the light? Why do forest trees have longer trunks than trees of the same kind that grow in the open (pages 53 and 54)?

CHAPTER EIGHT

THE BASSWOOD OR LINDEN TREE



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FIG. 35. Leaves and flowers of the linden.

THE basswood is a good tree to know and cultivate. It is also called lime, bee tree, whitewood, and linden. Both the European and American lindens are good shade and ornamental trees, but they need deep, rich soil and may require spraying to prevent injury by insect enemies. The leaves are large, heart-shaped, and not quite symmetrical, for one side of the base is longer than the other. In June and July the trees are full of fragrant, cream-colored blossoms, hanging in clusters from membranous bracts which are like narrow leaves (Fig. 35). Probably you have eaten honey made from the nectar in these blossoms, for they are one of the main sources of good honey.

Does the linden furnish the bees with nectar to help them or to serve some purpose of its own? Why are

the flowers fragrant, and why have they a different color from the leaves?

Uses of the wood. The sections which bee keepers put in the hives for the bees to fill with comb and honey are made of basswood. Many other kinds of wood, if used in this way, would give a disagreeable odor or taste to the honey, but basswood is free from these objectionable qualities. You can get a sample of basswood by taking a piece of such a section after the honey has been removed, or perhaps from a piece of a crayon box, for many crayon boxes are made of this wood. On the crayon box is the printing on the wood? Would it be as easy to print on any kind of wood as on basswood? Another name for the basswood is whitewood. Why? Can you name some kinds of wood that are lighter colored? Is basswood as heavy as a piece of oak of the same size? Name some kinds of wood that are heavier and some kinds that are lighter than basswood.

Properties of the wood. The thin boards used in making crayon boxes are not sawed in a mill, as most boards are, but are sliced with a long knife. After a short basswood log has been steamed, its side is pressed against a fixed knife as long as the log itself, and the log is made to revolve. In this way a thin layer of wood is peeled round and round from the log, giving a large sheet which can be cut into any desired size. Would it be as easy to do this with all other kinds of wood? With your knife try whether basswood is easy to cut. Is it easy to drive a nail into it, or to dent it with your finger nail? Is a thin piece of basswood as tough as a

thin piece of pine or cedar? Does it split as easily? Has it an odor? By actually testing the wood you can learn many of its properties.

At home you can probably find several things that are made wholly or partly of basswood. How about the furniture? Look not only at exposed parts, but also at the parts which ordinarily do not show. Examine also burnt-wood work, plaques, kitchen utensils, picture molding, small boxes of the kind used in mailing samples, and other articles of wood. When you find something made of basswood, see if you can tell why this kind of wood was used in making it. Carriage bodies are made of basswood because it is flexible and can be easily nailed. Which properties of basswood adapt it to use for small boxes? Do not be content with giving one or two properties; there are several. Likewise think of more than one property which makes it useful for each of the purposes for which it is commonly used.

Bast. Cut off a small branch from a basswood tree and examine the fibrous inner bark. Has it any taste? Can you get from it long strands, slender but tough? These are composed of bast fibers, which are particularly abundant in the linden; hence the name "basswood." One of the strong, slender strands you pull out from the inner bark of a basswood



FIG. 36. Bast fibers from the bark of a linden twig.

tree is made up of many bast fibers, each fiber only about one fifteen-hundredth of an inch in width.

Bast fibers strengthen the stems of flax, hemp, and many other plants. Bundles of them run through the stem and leaves like wires fixed in place and prevent the plants from breaking in the wind. Linen, twine, and rope are made of strands of such fibers. Those of the linden are used for making cords, fish nets, mats, and coarse cloth. Before raffia came into use, the basswood bark was used as a tying material in nurseries and green-houses. Corn shocks were formerly tied with basswood bark. The Russian peasants wear shoes made entirely of linden bark, and you are perhaps wearing shoes whose shanks are strengthened with basswood. In Russia, bags, bridles, and various other useful articles are made from linden bast.

Other uses of the linden. Make a list of the uses mentioned above, for linden trees and their products. Add to the list all other uses you can find. See if your father can add to your list. How many different uses in all have been listed by your class? You may not have discovered that the wood of the linden is used in making excelsior, paper, and fuel. Charcoal made from linden wood is used for tooth powder, medicinal purposes, artists' crayons, and in the manufacture of gunpowder.

From the blossoms of the linden perfumery is made, and from the seeds is extracted an oil similar to olive oil. The author has found the seeds in the gizzard of a wild swan, and they are probably eaten by other birds.

Tiers of leaves on the linden tree. The twigs and leaves of the linden grow only in a horizontal direction, not reaching up toward the branches above or down toward those beneath. This arrangement gives open spaces between the branches so that the sun can shine far in along each branch toward the heart of the tree. Each branch is able, therefore, to expose a flat layer of leaves to the light without having them overgrown and shaded by the branch above, and a linden tree shows tier after tier of leaves held out by the branches to the light.

Is there room to expose more leaves to the light by this arrangement, or by placing the leaves in a layer around the outside of the crown? What trees do you know besides the linden that have their leaves disposed in tiers? Do you know any trees that have their branches in circles with open spaces between the circles?

CHAPTER NINE

THE SYCAMORE

Beautiful even though stripped and bare,
Are the trees that are planted everywhere,
Winter's best beauty belongs to them,
To their giant trunks and feathery stem,
And they bravely stand in the silent wood
Like a patient life that is nobly good.

MARIANNE FARMINGHAM

THE sycamore is also called buttonwood and plane tree. It can be distinguished from other large trees by the dappled whiteness of the bark. The trunk is blotched and streaked, for the outer bark comes off in large, thin plates, exposing the newer bark within, which is smooth and greenish or whitish. On this account the tree may be recognized at a great distance. Sycamore trees have long trunks, and in the eastern half of the United States they grow larger than any other hardwood trees. At Washington, Indiana, stands a tree of this kind, with a trunk circumference of 42 feet. In Kentucky there was a sycamore with a hollow base that a family, in which were several children, used for a home. The sycamore thrives best in moist soil and is common along streams.

The oriental plane tree is a near relative of the sycamore and very similar to it. It is one of the very best trees to plant along city streets. It is more symmetrical than the native tree, grows fast, and is not often seriously infested by insects.

Leaves and fruit. The leaves of the sycamore are larger and less deeply lobed than maple leaves. Their width is greater than their length. The one-seeded

fruits are grown in balls an inch in diameter, which through the winter hang from the branches by slender stalks 4 or 5 inches long. The stalk sways in the wind and, if the wind is strong, the ball may strike a twig violently enough to loosen the fruits. Each fruit has a tuft of hairs at the base which sustain it in the air. Thus the seeds of the trees are borne long distances and are widely spread.



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FIG. 37. Base of a Pennsylvania sycamore. This tree is more than 9 feet in diameter at the ground.

Sycamore wood. The wood of the sycamore contains many large pith rays. It is hard to split and difficult to work, because the grain is interlocked by the fibers curving about among the rays. Much of it is used for tobacco boxes, because it is odorless and because the thin pieces can be nailed together without splitting them. It is not durable out of doors, but when quarter-sawed (page 103), so as to show the pith rays, it is much admired. For this reason it is sometimes used for furniture and interior finish.

CHAPTER TEN

LEAVES, BUDS, BLOSSOMS, AND BRANCHES

HAVING learned to recognize several kinds of trees, you will now be able to see more clearly how they differ

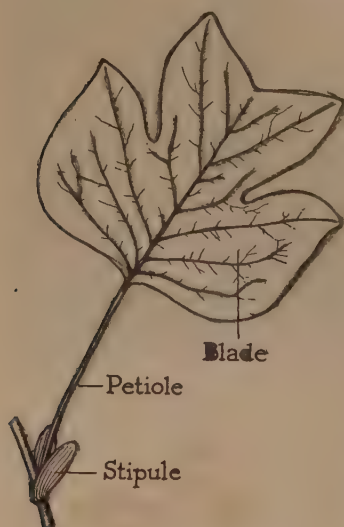


FIG. 38. The parts of a leaf.

in leaf arrangement, in size of the buds, in their blossoms, and in other ways. Attention to these points will help you in identifying other kinds of trees and in making observations on the trees you see from day to day. When you take up the study of botany, you will go more fully into the life of a plant and you will learn many facts that will give more meaning to outdoor life. In this chapter we shall discuss only a

few points that will help you to understand how a tree lives and to interpret some of the things you observe in the trees about you.

Parts of a leaf. A leaf consists of the *blade*, or expanded portion, and the *petiole*, or stalk. The veins are composed of vessels (tracheæ) for carrying water to the leaves, other vessels for taking the food away from the leaves, and tough fibers that help make a framework for the support of the softer parts. These vessels and fibers run through the petiole of the leaf into the

branch on which it grows. Some plants — e.g., the pea or apple — have small, leaflike organs called *stipules* growing at the base of the petiole.

The function of a leaf. Animals eat food that is already prepared for them, but plants must make their own food from water and other materials that they get from the soil and from the air. The leaves are the organs that make the food. In the chapter on maples you learned that sugar is formed in the leaves out of water and carbon dioxid (page 26). Sunlight supplies the energy for this work. Without it the leaves could not build up any food for the nourishment of the tree; a tree must therefore place its leaves so that the sun will shine on them. Turn a potted plant that has been standing near a window, halfway around. After a day or two notice whether the leaves have changed their positions. The leaves of trees as well as of other plants are able to move to positions that will enable them better to receive light, and the branches and twigs grow so as to bring the leaves to the light. Moreover, the leaves of each kind of tree have a definite arrangement on the branches. The most common of these arrangements are described below. Find an example of each and see whether it prevents the leaves from being shaded by other leaves on the same shoot.

Two-ranked arrangement of leaves. Cut off a small branch from an elm, with the twigs attached. Lay it on a table, the floor, or the ground and notice that without much pressure you can make every twig touch the flat surface. See if you can do this with branches from other trees. Notice that on the elm the leaves

are not arranged in the same way as on some other trees. If the leaves are gone, the scars or leaf traces will show where they were. In the elm they are arranged on opposite sides of the twig, and as the twigs grow where leaves were once, they also have this two-ranked arrangement — that is, they are in one plane. You can see this by looking up into an elm tree. The same arrangement can be seen in a beech, basswood, or dogwood, but most trees have a different arrangement. Is there any connection between the two-ranked arrangement of leaves and the arrangement of the branches in tiers as described in Chapter Eight (page 61)?

Five-ranked arrangement. If you take a vigorous upright shoot from a peach, apple, or poplar and imagine a line run from one leaf or bud to the next and on to the next and so on, you will find that this spiral line, after going twice around the stem, comes to bud No. 6. If the shoot is not twisted, bud No. 6 is over bud No. 1, No. 2 is two fifths of the way around from No. 1, and No. 3 is four fifths of the way around, so that after the line passes over five spaces and comes to bud No. 6, it is found to be five times two fifths, or ten fifths, of the way around, and thus directly over the first. This arrangement, which is a good one to prevent one leaf from shading another, is found on many kinds of trees. Notice whether the sixth leaf is high enough above the first not to shade it.

The two-ranked and the five-ranked or two-fifths arrangement is found on trees with alternate leaves. If leaves are opposite, like those of maple trees, is

each successive pair directly over the pair below? Do you see any advantage in this arrangement?

Leaves and leaflets. Ash, walnut, locust, and a number of other trees have compound leaves; that is, each leaf consists of several parts, any one of which taken by itself looks like a leaf. Instead of being called a leaf, however, the smaller part is called a *leaflet*.

Leaves and leaflets may be distinguished by the fact that where a leaf is attached to a



branch there is a bud; at the base of a leaflet there is no bud. Buds grow into branches or flowers the following season, and if there were buds at the base of the leaflets they would fall when the leaves are shed.

Leaf scars. Examine closely the twigs of maple, elm, buckeye, hickory, or any other trees you may find near your home. You will find on all of them scars left by leaves that were once attached to the twig. Does the size of this scar differ in different kinds of trees? How do you account for the difference?

The dots which are so plain on some leaf scars show where bundles of tiny fibers and vessels passed from the stem into the leaf to support the leaf, and to supply it with sap and carry away the food which it has manufactured to feed the other parts of the tree. These bundles spread out in the leaf to form the principal veins. In compound leaves one bundle may go to each

FIG. 39. Palmately compound leaf of buckeye. The leaf of the ash is pinnately compound (Fig. 30).

leaflet. Count the dots ("horseshoe nails") in the scar of the horse-chestnut or some other tree with compound leaves, and see if the number is the same as the number of leaflets.

In those trees which shed their foliage in autumn, a layer of thin-walled cells forms at the base of the petiole where it is attached to the branch. When it is time for the leaves to fall, the walls of these cells break down and the leaf is cut off from the tree. Sometimes an unusually early killing frost prevents the breaking up of the cells of this separatory layer and the leaves cling to the tree much longer than they usually do. The twigs of some trees and many kinds of fruit when ripe are allowed to fall by the formation of a separatory layer like that which cuts off the leaves. In winter try whether a willow twig will break easily from the tree. Would this be an advantage to the tree if it were overloaded with snow and ice?

Buds. At the base of the petiole is a bud ready to grow the next spring. Open and examine the buds of a fruit or shade tree. A leaf bud is an unexpanded branch, and in the buds of some trees little leaves on the sides of the branch are already formed. The branch is of course very short and the leaves very small, but all that the bud needs to do to become a leafy shoot is to expand and grow. Can you find the young leaves in the bud? Does the same bud ever produce both leaves and blossoms? Does a twig bear leaves more than one year?

The buds at the ends of shoots are called *terminal* buds. Those on the sides of shoots are called *lateral*

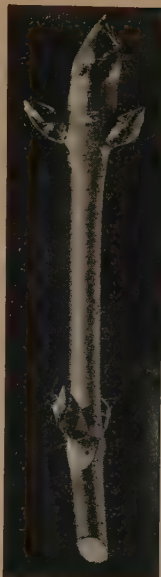
buds. What is the position of a lateral bud with respect to the base of the leaf or the leaf scar?

The outer parts of a bud are to protect the delicate parts within. If these were unprotected, in what ways might they be injured? Examine the protective coatings. How many devices do you find for protection?

What differences do you notice between the buds of different trees? If some one were to bring you a bud he had cut off from a hickory or maple or poplar tree, could you tell from which tree it had come? What other trees could you recognize by the buds?

Blossoms. Botanists think of a blossom as a leafy branch that has failed to grow out long. The parts of the flower, which are supposed to be very much modified leaves, are crowded close together because of the shortness of the branch on which they grow. Although the organ or organs at the center of a flower (the pistil or pistils) do not ordinarily resemble leaves, yet there are good reasons for thinking that they are really leaves which instead of growing broad and flat have developed so as to inclose the seeds.

A flower bud as well as a leaf bud may therefore be considered an unexpanded branch. The flowers of



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FIG. 40. Twig of a horse-chestnut, showing lateral buds and terminal buds. The leaf scars are just below the buds. The lenticels may be seen as small dots scattered over the twig.

many forest trees lack the *corolla*, or group of petals, which makes the blossoms of fruit trees so attractive. They have, however, the essential parts of the flower, the *stamens* and *pistils*. The stamens of flowers produce a yellow powder called *pollen*. In the lower part of the pistil, called the *ovary*, the *ovules* (little eggs) which are to grow into seeds are produced.

Seeds cannot be produced by trees or other plants unless pollen from the same kind of tree or one very similar falls on the tip of the pistil, which is called the *stigma*. The stigma is covered with a sweet, sticky liquid, and the pollen grain, when it lodges upon the stigma, absorbs the liquid and grows into a tiny plant which extends down inside the pistil to the ovary. In the lower extremity of this tiny plant is a minute cell which unites with an egg cell that grew in the ovary. This union is called *fertilization*. After it has taken place, the egg cell divides, giving rise in time to a number of cells so arranged as to form an *embryo* with tiny stem and leaves. By examining acorns, beans, or other seeds that have been softened by soaking them in water, you can find the embryo. This is the part of the seed that grows into a plant like the plant from which the seed came.

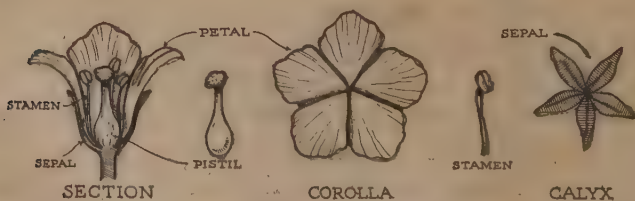


FIG. 41. The parts of a complete flower.

the birch and the the stamens and pistils are not found in the same flower, and in willows, poplars, and the box elder they are not even on the same tree. Would a tree that had only flowers with stamens produce seed?

Growth of branches.

When a leaf bud grows, it pushes out a certain length which marks the amount of growth of the branch for that season. Then a second bud forms on the tip of the branch, and this in turn grows the next season. Year by year a branch increases in length by growth at the tip. Does a branch bear leaves on the part which grew the previous season, or are the leaves always found on twigs and tips of branches that are the same age as themselves?

With a sharp knife cut off from any tree which can well spare it a branch with branchlets attached. Try to tell by examining the bark how much of the branch grew during the last growing season, and how much the preceding year. Scars left on the bark when the bud scales fell off mark the places where growth was renewed after the winter's rest. A slight difference may



U. S. Forest Service

FIG. 42. Catkins of the hazel. Each catkin is a collection of small flowers.

be noticed in the color or freshness of the bark above and below these marks. By this means tell the year when each part grew, counting back from the tip to the base. Count the rings of wood that show where your knife severed the branch. If they are hard to count, try to make a smoother cut, which may be more easily done if you cut it obliquely rather than straight across. If you are careful in counting, you will find an agreement in the number of years indicated by the wood and the number indicated by the bark. On some branches it is hard to be sure about all the places where growth was suspended.

In determining the age of a branch you have cut from the tree, do you get the same result whether you start from the tip of the main shoot or from the tip of one of the branchlets? If you cut across a branch above and also below a place where growth began anew in the spring, do you find a different number of rings of wood?

Opposite and alternate branches. Since branches grow from buds that are at the bases of leaves, trees that have opposite leaves have opposite branches also. Some buds fail to grow, or a branch may break off, leaving only one branch at some nodes, but you do not need to look long into a maple or ash tree to see many places where there are pairs of opposite branches. In the elm or the birch, which have alternate leaves, you will find no pairs of opposite twigs. You can therefore tell by examining a tree, even in winter, whether its leaves are alternate or opposite.

Some experiments with leaves and branches. Apply a drop of dilute tincture of iodine to starch paste, potato,

and bread. Note that the iodine causes the starch and the foods that contain starch to turn blue. Test sugar, milk, meat, and other food materials that are free from starch and observe that they do not give this color when iodine is applied to them.

Pull a leaf on which the sun has been shining for several hours and place it in warm alcohol. Keep it in the alcohol until the green coloring matter of the leaf has been removed, taking care not to set the alcohol on fire. When the leaf has become colorless, apply the iodine test to it. Does it contain starch? If so, where did this starch come from?

Pull a leaf at sundown and put it in the dark. The next morning remove the green coloring matter from this leaf and also from a leaf that has remained on the tree all night. Test both leaves with iodine. Which one contains starch? What became of the starch that was in one of the leaves?

Cut off leafy shoots of maple, willow, or other trees. Set the lower ends of the stems in water colored with red ink, and place the shoots in the sun. After a half hour cut the stems across and note whether the red color is in the bark, wood, or pith. What part of the stem conducts the water up to the leaves? Perhaps you may be interested in seeing how far the colored water rises in an hour. Sometimes, when shoots are cut, air bubbles are drawn into the ends of the vessels and the ascent of the water is blocked. This difficulty may be overcome by cutting off under water a short section from the lower end of each shoot.

CHAPTER ELEVEN

POPLARS



FIG. 43. Leaves and catkins of aspen (left) and leaves of cottonwood (right).

THE leaves of poplars, especially those called aspens, quake in even a slight breeze. The sound they make has been compared to the patter of rain. Secure a leaf from a poplar and examine the leafstalk just below the blade of the leaf. Do you understand why the leaves of a poplar are stirred by even a light breeze?

The flowers of the poplar are borne in long, drooping *catkins* which appear in early spring. The staminate flowers are borne on one tree and the pistillate flowers on another tree; thus only certain trees produce seed. The small seeds are provided with tufts of fine white hairs. These are blown about by the wind, sometimes for long distances.

The cottonwood. The cottonwood, or necklace poplar, is found from Quebec to Florida and west to the Rocky Mountains. It produces as fruit little capsules strung along a curved stem like beads in a necklace. They mature and split open in the spring, and the seeds with their cottonlike tufts of hairs are scattered by the wind. They do not wait till the next spring to sprout, but like some maple seeds germinate at once.

As the cottonwood will grow where other trees do not thrive, it is very widely distributed. On recently formed sand spits in rivers and lakes the soil is too poor for any trees except cottonwood and willows, for it contains no humus, or vegetable mold, such as you can find in any woods where trees have grown and shed their leaves year after year. Generally speaking, the cottonwood is likely to be short lived, but some cottonwood trees are more than a century old and are among the largest trees east of the Rocky Mountains.

The wood. Cottonwoods abound along streams in the plains where other trees are



H. B. Ayer

FIG. 44. Giant cottonwood near Shakopee, Minnesota. It is over 9 feet in diameter and 130 feet tall. Note the man near the base.

scarce. In such places people use the wood for fuel and for other purposes. Boards made of it warp badly, especially when exposed to moisture, and are inferior in both strength and durability to boards made from most other woods. The tree is a very rapid grower, sometimes increasing in diameter 10 inches in as many years. The wood is soft and light colored and is much used for paper pulp.

Objections to the cottonwood as a shade tree. The leaves of the cottonwood, being smooth, do not catch soot and dust like those of the elm. On this account and because of its rapid growth, this tree (especially the variety known as the Carolina poplar) has been planted along many city streets. Like many other things that are cheap, the cottonwood usually proves unsatisfactory. It is attacked by several kinds of insects and is likely to be short lived. It is not ornamental, and its capsules and cottony seeds — and in summer its leaves and twigs — litter the ground. Its roots, sometimes more than 100 feet long, in their search for water send their rootlets into drains and obstruct the drainage; they have been known even to break through the cement linings of cisterns. Some cities have passed ordinances forbidding the planting of this tree.

Aspens. The American aspen is a small species of poplar with light-colored bark and soft, light wood. It is found through the cool portions of North America and grows in poor soil, often springing up extensively where woods have been burned. Beavers cut it down with their strong, sharp incisor teeth, using it to build

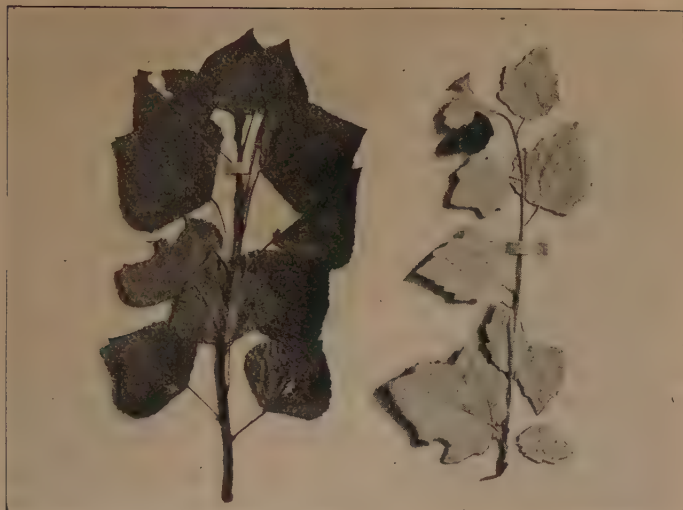


FIG. 45. Leaves of Lombardy poplar (left) and silver poplar (right).

their dams and lodges and eating for food the bark and water-soaked wood. Its wood, like that of other poplars, is much used for making paper. A similar species of aspen grows in Europe.

Lombardy poplar. The tree that is best known under the name of "poplar" is one which is not a native of this country but has been brought from Europe. It is called the *Lombardy poplar*. Its branches are ascending, so that the tree is like a spire and becomes very tall without spreading out. This variety is often prominent in French and Italian landscapes. Driveways that lead back from main thoroughfares to country mansions are often bordered by Lombardy poplars.

Silver poplar. The white or silver-leaf poplar, also from Europe, has quite a different habit from the Lom-

bardy poplar, for its branches are spreading. Its leaf-stalks are only slightly flattened, and its leaves are cottony white on the under side. Some people incorrectly call it the "silver maple." It spreads by means of the roots, the sprouts which it sends up forming within a few years extensive thickets that are difficult to eradicate. On this account it is not a desirable tree to plant.

Root systems. The root system of poplars and most other trees is composed of many slender branches of nearly equal length. Such a system of roots is called a *fibrous root system*. On the other hand, an oak, a pine, or a walnut or other nut-bearing tree has a *tap root*; that is, it has one large root going down deep into the ground, with smaller roots branching off from the side. The radish and dandelion are examples of herbs with tap roots. Grasses, corn, and other grains have fibrous root systems.

The combined length of all the roots of so small a plant as a wheat plant has been found to be more than



FIG. 46. A cottonwood seedling less than 1 year old. The roots have reached a length of from 3 to 4 feet.

1800 feet. It would be difficult to tell how far all the roots of a big cottonwood tree would reach if placed end to end. Figure 46 shows the roots of a cottonwood tree less than one year old. This tree grew in sandy soil. In arid parts of the Southwest the mesquite has been known to send its roots to a depth of 60 feet in search of water. In ordinary soils the roots of trees must remain nearer the surface, where they



Wm. H. Moon Co.

FIG. 47. Young Lombardy poplars.

can get air as well as water. If the soil is not drained and water completely fills the spaces between the soil particles, the roots of most trees will die for lack of oxygen.

Functions of roots. The roots of most trees do not serve, like those of the silver poplar, to reproduce the tree, but they have other very important functions. They anchor the tree in its place, and they gather from the soil and supply to the tree the water and mineral materials that it needs. Roots excrete substances which help to dissolve limestone and other mineral materials in the soil. In this way they secure more mineral matter for the tree. If the ground on one side of a tree is well watered and on the other side dry, the roots grow toward the water.

CHAPTER TWELVE

THE TULIP TREE

I care not how men trace their ancestry,
To ape or Adam; let them please their whim;
But I in June am midway to believe
A tree among my far progenitors,
Such sympathy is mine with all the race,
Such mutual recognition vaguely sweet
There is between us. Surely there are times
When they consent to own me of their kin,
And condescend to me, and call me cousin.

LOWELL

THE grandest tree of the Appalachian forest and the Middle states belongs to the Magnolia family and is known as the *tulip tree*. The members of this family have large, showy flowers, very different from the inconspicuous flowers of most of our forest trees. Many tulip trees have been found that are more than 130 feet tall. They grow in the forests from southern Vermont to northern Florida and west to the Mississippi River. In the mountains of Tennessee and North Carolina specimens with magnificent straight trunks 7 or 8 feet in diameter may be found, and the early settlers west of the Appalachians found many of these trees with tall, clean trunks 4 to 6 feet in diameter.

Leaf, fruit, and flower. You can tell a tulip tree by its peculiar leaf, which looks as if the tip had been cut off, or by its fruit, which is a sort of cone, not hanging but standing upright. In the course of the winter the scales of the cone fall, leaving the central axis still standing. In the base of each scale is a seed, and the scale serves as a parachute to carry the seed away.

The yellowish green flowers, tipped with orange, are

shaped like tulips, although not so bright. Persons who are not very observing may pass under a tulip tree in blossom in May or June and fail to notice the flowers among the leaves, but no one fails to admire them when his attention is once called to them.

The "clean" trunk of the tulip tree. The tulip tree is a favorite with lumbermen, not only because the trunks are long and straight but also because they are "clean" to a great

height. By a clean trunk is meant one that is free from limbs, so that the lumber made from it will be free from knots; for knots appear in the wood where limbs grow out from the trunk of a tree.

Trees standing close together in the woods grow tall because each receives light mainly from above, and they produce clean trunks because the lower branches, being shaded, die and fall while they are still small. Trees growing in open places do not grow so tall as those in the forest, but they have a wider spread. Their lower limbs persist and attain a large size. Such trees do not make lumber of high grade. Few other trees found in

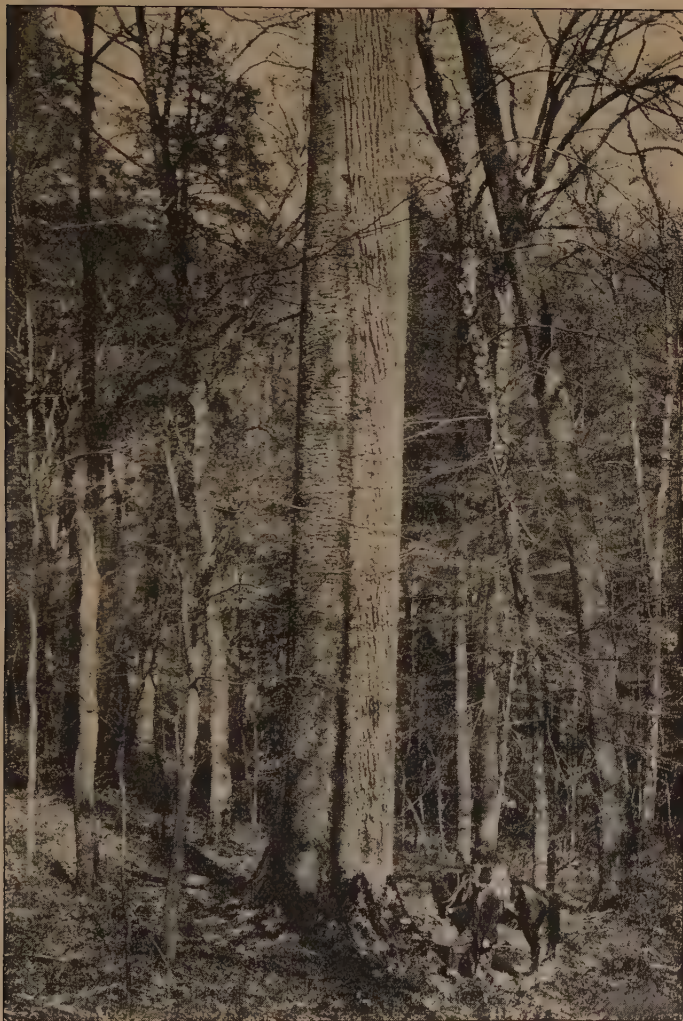


FIG. 48. Leaves and flowers of the tulip tree.

the eastern part of the United States, even when they grow in the forest, produce so clean a trunk as the tulip tree.

Names and uses of the wood. Tulip trees are still an important source of lumber, which is sold under the name of "yellow poplar," although the tree is quite different from a poplar. Like basswood, the wood of the tulip tree is often called "whitewood," but neither of them is as white as holly or spruce. Tulip wood is light, soft, and easily worked, nails well, and does not split or warp readily; hence it is used for interior finish, boat building, carriage bodies, pumps, woodenware, shelves, the bottoms of drawers, and many other purposes. The Indians used the trunks of these trees to make canoes or dugouts, for they are large, long, straight, and much easier than most trees to hollow out with stone tools and fire. Paint adheres to the wood of the tulip tree much better than to hard pine or some other kinds of lumber, and "poplar" boards are a favorite material for siding houses.

The tulip tree as a shade tree. The tall, straight trunk, light green foliage, and showy blossoms of the tulip tree entitle it to distinction among ornamental trees. It should be planted more generally, as it has few insect enemies, grows well in moist, well-drained, deep loam, and is very handsome even when not in blossom. It endures smoke but needs plenty of light, and it does not stand severe pruning. It cannot be transplanted successfully in the fall, for its roots are very tender and should have a chance to grow immediately after the tree is transplanted.



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FIG. 49. Tulip tree in Graham County, North Carolina.

Cone-shaped trees. A young tulip tree growing in the open is beautifully symmetrical and distinctly cone-shaped. A young sycamore, pine, or cedar has the same shape. Why do the lower branches on these trees grow out longer than the upper branches? What is the function of the leaves on a tree and what would happen to the leaves on the lower branches if these branches were not longer than the upper ones? Why do not the lower branches of a Lombardy poplar find it necessary to grow out horizontally and widen the lower part of the crown?

To estimate the height of a tree. When we look at one of our great tulip trees, we often wonder what the height of such a tree is. This can be determined in a very simple way without climbing the tree.



FIG. 50. Leaves and flower of the long-leaved magnolia. The magnolias are close relatives of the tulip tree and are favorite shade trees in the South.

Set a short pole in the earth near the tree. Measure the height of the pole, the length of its shadow, and the length of the shadow of the tree. The height of the tree may then be computed as follows: Multiply the length of the tree's shadow by the height of the pole, and divide the product by the length of the pole's shadow. The proportion may be expressed thus: The height of the pole is to the length of its shadow as the height of the tree is to the length of its shadow.

the height of the pole : the length of its shadow :: the height of the tree
: the length of its shadow

The pole might be 6 feet long, and its shadow 9 feet. The shadow of the tree might be 60 feet. We should then have this proportion: $6 : 9 :: x : 60$, where x represents the height of the tree. Our answer to the question then is: $6 \times 60 = 9 \times x$, or $x = 40$, the height of the tree.

CHAPTER THIRTEEN

THE CATALPA OR INDIAN BEAN



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FIG. 51. Leaves and flowers of the catalpa.

CATALPA trees grow wild in some of the Southern states and in the southern part of Indiana and Illinois, and about many towns in the Eastern states one sees them planted as shade and ornamental trees. The leaves, which are very large, appear later than those of most Northern trees. The flowers form large, showy clusters; they are creamy white, more or less spotted with purple or brown, and marked inside with two rows of yellow blotches. They appear in early summer after the blossoms of most trees have gone. The fruit consists of pods, sometimes 20 inches long, that hang in clusters

throughout the winter. In late winter and spring these pods split into two valves. The numerous flat seeds have a winged margin and a tuft of long, white hairs. What purpose do these serve?

Uses of the catalpa. Because of its durability in the ground catalpa wood is much used for railroad ties and still more for posts. Osage orange makes the most durable post, and the yellow locust and red cedar are next best; but in many places the catalpa can be raised with less trouble than these trees. For satisfactory growth it requires a deep, fertile, porous, and well-drained soil.

The catalpa has been extensively planted for fence posts on the prairies of Kansas and Missouri, and also in Ohio and Indiana. There are two species, the common catalpa and the hardy, or western, catalpa. The latter grows taller and straighter than the common catalpa and is preferred for planting.

Enemies of the catalpa. Both species of catalpa are fairly hardy; but they require considerable light and moisture and are subject to leaf spot, a fungous disease that can be checked by spraying. Their leaves appear to be less palatable for most insects than those of some other shade trees, but the catalpa sphinx has spread over much of the region where the tree has been cultivated and is now becoming a serious pest. The sphinx, or hawk moth, lays eggs in large masses on the under side of the catalpa leaf. The caterpillars, or larvæ, that come from these eggs feed on the foliage and grow to be 3 inches long. They resemble tomato worms, but are yellow and black instead of green.

Durability of woods. Decay in wood is caused by *fungi*. These are small plants that grow in the wood and use it as food. Some woods have in them resins, gums, oils, turpentine, coloring matter, and other substances that prevent the growth of fungi in them. Such woods are very durable, and in buildings in China and in Europe wood that has lasted for many centuries may be found. Yellow pine is valuable for porch floors, because the wood is protected by resin in the boards.

Why are houses painted? If a house is not painted until decay has started in the wood, will the decay continue after the painting is done? If the timbers used in the walls of a house are partly decayed when the house is built, will the decay continue after the house is completed? Will decay spread from one board to another if the two are placed in contact? Does a post decay more quickly in the air, at the surface of the ground, or when buried deep in the ground? Does wood that is immersed deep in water decay? Why and how are railroad ties creosoted?

The durability of woods is affected also by the amount of moisture they contain, and probably also by the structure of the wood and the amount of food stored in it. Generally speaking, wood from a tree that has grown slowly in a forest is more durable than wood from a tree that has grown rapidly in the open, and in many species of trees the heartwood is more durable than the sapwood.

Name some kinds of wood that decay in a few years. What kinds are more durable? Name several ways of treating wood to make it last.

CHAPTER FOURTEEN

HICKORY AND WALNUT

THE seeds of all the trees we have studied up to this time are light and are dispersed by the wind. The fruits of nut-bearing trees are too heavy to be distributed in this way. They may roll down a hillside, be borne along by currents of water, or be carried by animals and dropped where they will grow. The kernel of a nut contains a store of food for the young plant, and the hard shell and bitter covering help to protect the little plant and its food supply from animals that might otherwise devour them. How are chestnuts protected while they are growing?

Hickories. In the fall hickory trees are easily recognized by their nuts. How many kinds of hickory nuts do you know? If you live in a region where hickories flourish, you can probably find five or more species within a mile or two of your home. Big shellbark, small shellbark, mockernut, bitternut, pignut, and pecan are hickories. They differ with respect to leaves, buds, and bark as well as in their fruits. Hickories all have compound leaves, which means that each leaf consists



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FIG. 52. Lone hickory near Edgewood, Maryland.

of several leaflets. How many leaflets have some of the kinds of hickory that you know? What other trees besides hickory have compound leaves? How does the hickory differ from the ash in the arrangement of its branches and leaves?

Hickory wood. Hickory is one of the best kinds of wood for fuel, because it is heavy, even when seasoned, and so does not burn out quickly. A cord of it lasts longer and gives more heat than a cord of any light wood. What other kinds of wood are valued for fuel? When it is sound and free from knots, hickory is too valuable to be used for fuel. Probably you cannot find an ax handle made of any other kind of wood. Hammer handles, pick handles, ladder rounds, some toothpicks, and many other things requiring strength and elasticity are made of hickory. The spokes and rims of wheels for carriages are usually made of this wood.

Walnut wood. The wood of walnut trees is now very much more valuable even than hickory wood. Although not so strong, it is easier to make smooth, and the heartwood, which has a dark color, is prized for gunstocks, cabinet wood, and furniture. For many years it has been exported to Europe. Half a century ago, when walnut was still abundant and men failed to realize how valuable it would become, walnut trunks were often split into fence rails. These lasted many years, but as land and wood have become more valuable most of the rail fences have been replaced by wire fences. Since the wood is so durable, old walnut stumps have been cut into veneers, which are thin pieces used to cover some cheaper wood. Old and worn furniture of solid walnut

has been made into veneers for new furniture. What part of the black walnut do you think might be used for dyeing cloth?

Walnut and butternut. Both black walnut and white walnut, or butternut, are found in most of the eastern half of the United States except near the Gulf and South Atlantic coast. How can you tell a butternut tree from a black walnut without the fruit?

Which has the lighter-colored bark? Which usually has the longer trunk? Which has the more sticky leaves? Which has the broader leaflets? Which has the stronger, or more pungent, odor? Which has a cushion of hairs on the upper margin of the leaf scar? How does the pith of walnut and butternut differ from that of other trees?

Nuts in commerce. The cultivation of nut-bearing trees as a source of food is an important industry. The Persian walnut, often called "English walnut," is a native of Asia and southeastern Europe. It has been cultivated for centuries in the Mediterranean region. California sends each year more than a thousand car-



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FIG. 53. Trunk of shagbark hickory near Sewanee, Tennessee.

loads of these delicious nuts to Eastern markets, and hardy varieties of the tree are beginning to be grown in our Eastern states. Nevertheless, some thirty million pounds of walnuts a year are brought to the United States from France, Italy, and other foreign countries.



FIG. 54. Cells from the shell of a pecan. Note the thick walls of these cells, which give the hardness to the tissues.

Pecans are the most important nuts in the market that are produced by trees native to America. Pecan orchards have been planted in many places in the South Atlantic and Gulf states and produce nuts much superior to those of the wild trees. Why are these nuts more in demand than those of other species of hickory trees?

The hard tissues of plants. Examine a fruit of a walnut or hickory tree. The shell is dense and hard. These hard parts of plants are formed by the thickening of the walls of the cells that compose them. Thus in the shells of some nuts the protoplasm of the cells builds up the walls about them until the cavities of the cells are almost filled. This makes a tissue which has little air space in it, and is in consequence very hard. Not only in seeds and fruits, but also in the outer layers of many plants and in other places, are these collections of hard cells found. Where their walls are very thick they are called "stone cells."

CHAPTER FIFTEEN

OAKS

Full in the midst of his own strength he stands,
Stretching his brawny arms and leafy hands,
His shade protects the plains, his head the hills commands.

VERGIL

OAKS are among the most common and useful of trees. Nearly three hundred kinds of oak are known, of which about fifty grow wild in the United States. There are probably few areas of the size of a county that contain more than ten species of oak, though in one piece of woodland nine different species were found. Because of their abundance and the many valuable properties of their woods, oaks are the most important of all the hardwood trees of our forests.

Oak leaves. A collection of the leaves of the different oaks that grow near your home is easily made and will help you to know the trees. The leaves of most species are lobed, but the shape of the lobes is different in the different species. Look at Figures 55 and 56 or at specimens, and tell how a white-oak leaf differs from a red-oak leaf. Which species of oak have leaves that closely resemble each other? How can you tell them apart? Does any species of oak retain its leaves long after they have lost their green color?

Acorns. The acorns as well as the leaves of different kinds of oaks differ and should also be collected. Pin oaks have small and nearly hemispherical acorns, which in many cases are striped. Bur oaks have large acorns with deep, shaggy cups or cupules, and are therefore also called "mossy-cup" oaks. Red oaks have large



FIG. 55. Leaves and acorns of the white oak (A) and of the bur oak (B).

acorns with shallow, saucerlike cupules. Which kinds of oaks have acorns that are good to eat? What birds eat them?

When the crop of acorns is abundant in parts of our Southern states, the hogs that run in the woods fatten on them. Cattle, deer, and squirrels also eat them. The Indians esteemed them as an article of food; in southern Europe the people boil and eat them, and we too should do this if we were not well supplied with better food.

Uses of oak bark and wood. In the bark of some kinds of oak a dark-colored substance called *tannin* is deposited very abundantly. This is used in tanning hides to make leather. Why are untanned hides less useful than leather for making shoes, harness, and other articles? Have you ever seen a piece of raw hide? Corks are made from the bark of an oak that grows in Spain and in northern Africa.

Oak wood is heavy, hard, and strong; it has wide

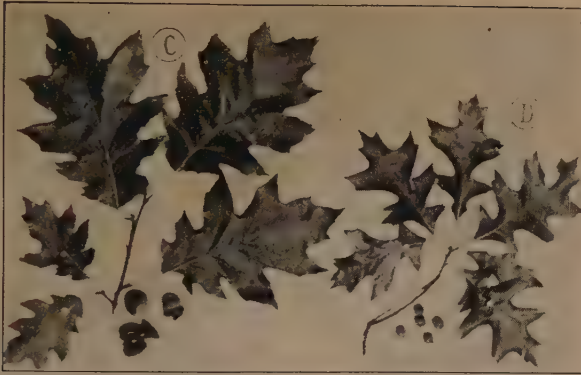


FIG. 56. Leaves and acorns of the red oak (C) and of the pin oak (D). The lobes in the leaves of the red oak point forward. In its near relative, the black oak, they point to the side.

pith rays that give many of the boards a mottled appearance, and many of the species are very durable. For fuel how does oak compare with other kinds of wood? What properties of oak adapt it for floors? for the making of furniture? of wagons? of ships? What other things are made from it? Why? Verify by actual test all the properties of oak that you have named.

Galls. On some oak leaves and branches you will find peculiar growths which you might suppose to be fruits, if you did not know that the fruit of the oak is an acorn. These peculiar growths are *galls*. Some twenty-five kinds of galls have been found on white oaks alone. Open a gall and look for a tiny, wormlike creature. It is not a real worm, for, if you had not disturbed it, it would in time have developed into a fly. Indeed, it came from an egg laid by a fly and is the maggot of the fly. Like the caterpillar and grub, it

*Journal of Heredity*

FIG. 57. Giant white oak near Amelia, Virginia. It has a height of 118 feet and a spread of 128 feet.

*Journal of Heredity*

FIG. 58. Trunk of the same tree. The circumference is more than 15 feet at a height of 6 feet from the ground.

is the larva stage, — the stage which follows the egg of an insect and during which it eats a great deal and grows fast. The little gallfly lays an egg beneath the skin of the leaf or twig, and when this egg hatches, the larva feeds on the juices contained in the leaf or twig. The abnormal growth (the gall) which the plant makes around the larva serves to protect the young insect from other insects and from birds.

Some galls are quite pretty. A collection of a dozen or more kinds would form an interesting exhibit in a schoolroom. Black ink is made from copperas and certain oak galls called "nutgalls," combined with a little dextrin or gum arabic, which is added to make it adhere to the pen. In Hungary and the Balkan States

certain oak galls are gathered and sold for tanning, and pyrogallic acid, which is used in photography, is made from them.

Oaks as shade trees. Besides the usefulness of their wood, bark, acorns, and galls, oaks are desirable as shade and ornamental trees. Oaks from the original forest, left standing after the land has become the site of a town or city, are often highly prized. The red oak is considered one of the best of all our shade trees. It is suitable for planting along broad streets. This species and the scarlet and pin oaks grow more rapidly than most of the other oaks. They are desirable as shade trees on account of their durability, symmetry, beauty of foliage, and comparative freedom from injury by insects or fungi.



Pan-American Union

FIG. 59. Live oak near Sutherland Springs, Texas. The branches are draped with Spanish moss.



U. S. Forest Service

FIG. 60. Young pin oaks on Pennsylvania Avenue, Washington, D. C.

Have you seen many large oak trees? How old do you suppose they are? How do live oaks get their name? Where do they grow? Which kind of oak do you consider the most valuable? Why?

Relatives of the oak. To the same family as the oak belong the beech and chestnut. All these trees produce staminate and pistillate flowers on the same tree. The flowers have no corolla, and the pistillate flowers are rarely noticed. They give rise to nuts which have no partition and contain but one seed. The seed or meat contains nourishment to start the growth of a new tree. Beechnuts, chestnuts, and acorns constitute a large part of the food of many birds and mammals.

CHAPTER SIXTEEN

FIGURES IN WOODS

IN floors, walls, doors, and furniture we see lines and patterns in the wood. Some of these are very beautiful, and woods that have marked figures in them often bring a high price. These figures are due to the annual rings and pith rays, and it is interesting to study out just how a tree has been cut to make any given pattern that we see. A study of these markings will help you in learning to identify woods also, and from it you will learn to appreciate better the beauty of furniture and other articles that are made of wood. Ash is a good wood for the study of marking caused by annual rings; and the wood of many evergreens likewise shows these rings well. Oak, sycamore, and cherry often furnish beautiful examples of markings due to pith rays.

Transverse, radial, and tangential sections of wood. If we cut across a tree trunk, we make a *transverse* section. On such a section the annual rings appear as circles and the edges of the pith rays appear as lines.

If we cut the trunk lengthwise through the center, we make a *radial* section. Such a section shows the sides of the pith rays running across the cut surface,



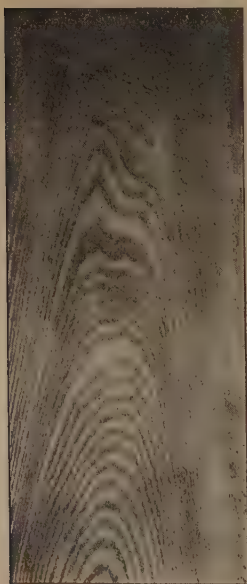
FIG. 61. Diagram to show the patterns made by the annual rings in a board cut from the side of a log.

sometimes somewhat obliquely, and the edges of the annual rings running lengthwise of it.

If we cut the trunk lengthwise but not near the center, we make a *tangential* section. A tangential section exposes the ends of the pith rays and cuts obliquely through the annual rings. In such a section the annual rings appear wider than in a radial section.

In a board the transverse section shows at the ends; the flat surfaces of boards show either a radial or a tangential section or a section intermediate between them.

The patterns in an ash board. Find if possible an ash board or a desk or other piece of furniture made of ash. The annual rings will show plainly because, where conditions are favorable, ash grows fast and makes wide rings and also because ash wood is ring-porous and there is a strong contrast between the springwood and the summerwood. If the wood has been finished, the springwood will be darker because the large pores are filled with the dark filler.



American Forestry

FIG. 62. An ash board. Can you explain the markings in the board?

In a radial section the edges of the annual rings will be seen as lines lengthwise of the wood (Fig. 62). In a tangential section the pattern is more complicated, but it can be understood

if you will think of the trunk of the tree as made up of thin-walled columns tapering upward (page 18), the grain of the wood as more or less twisted, and the tree itself as not perfectly straight. Nearly all tree trunks are somewhat crooked, and if one of the hollow columns, which represents the growth of one year in such a tree, were to be laid bare, it would be more or less crooked or bent. Therefore, when the saw runs straight through the log lengthwise, it cuts the wood columns in vari-



Southern Lumberman

FIG. 63. Curly cypress.

ous ways and exposes the rings in curved instead of straight lines.

After examining several ash boards in furniture or elsewhere, see if you can explain the patterns in them. Can you tell by the figure what part of the tree trunk the board came from and what part of the board was nearest the heart of the tree? If the end of the board can be seen, an examination of the rings that show there will help you in your study. Continue your study by



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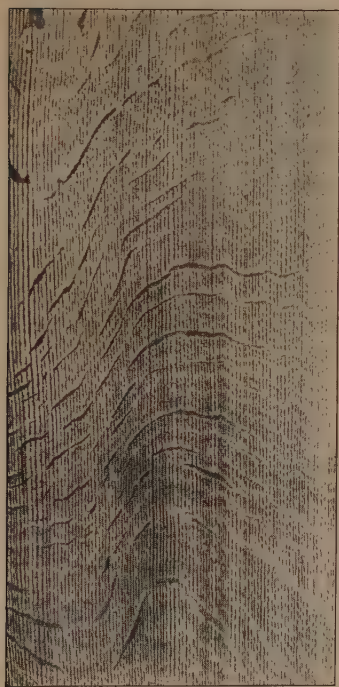
FIG. 64. Curly cherry. When the knots are cut through, the annual rings in them make patterns like those shown in Figure 63.

examining patterns in other woods that show distinct annual rings.

Patterns in oak. In oak the conspicuous patterns in the wood are due to the wide pith rays as well as to the annual rings. The rays appear as light spots, or "mirrors," in the finished wood.

A tangential section exposes only the edges of the rays, and a board must be cut by a radial section in order to show the broad sides of the rays. The rays are very thin and the saw usually passes in and out through them as it goes through the wood, so that you will see only irregularly shaped portions of them showing on the surface of the board. In some places, however, you may find a ray running for some distance across or along the board. In a board that has been given a golden oak finish the large tracheæ will show as dark, fine grooves in the wood and the pith rays as light spots and bands. The dense bundles of wood fibers, which form the greater part of the wood, have an intermediate brownish tone.

Quarter-sawed oak. Much oak is “quarter-sawed” to make the rays show on the surfaces of the boards. The log is first sawed in halves, and then each half is divided in the center. Then the boards are cut from the faces of these quarters. By this method of sawing the flat surface is made to show the edges of the annual rings running lengthwise of the board and, what is more striking, the “mirrors” or broad surfaces of pith rays. When quarter-sawed the boards are not only more



Southern Lumberman

FIG. 65. Quarter-sawed white oak, showing the “mirrors” or pith rays.



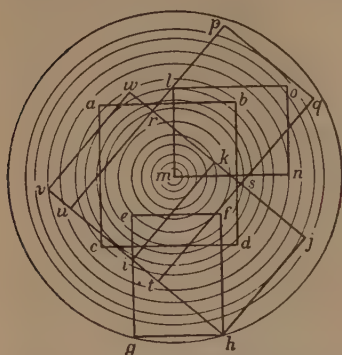
Southern Lumberman

FIG. 66. Short-leaf pine, showing patterns made by annual rings.

beautiful, but also less likely to shrink and warp (page 49). This kind of sawing requires more time and skill

than plain sawing, but a better product is obtained.

When a tree is sawed in the ordinary manner a few of the boards will be "quartered," and there are several methods of sawing a large log so that many of the boards will be "quartered."



U. S. Forest Service

FIG. 67. Possibilities of cutting timber from a log with reference to the grain. The strength of a column or beam depends to a considerable extent on the way it is cut from the tree.

Several kinds of wood besides oak are also frequently quartered and thereby made more valuable for furniture and other uses. Long-leaf pine for

flooring, spruce for violins and for sounding boards in other musical instruments, and tulip wood for siding are sawed in this way. All staves for oil and liquor barrels and for kegs are quarter split or sawed; they make a better barrel because they shrink less than if cut the other way. Quarter-sawed pine boards are better in a floor than boards sawed in the ordinary manner, because the annual rings are then exposed on their edges and the floor is less inclined to splinter. Many woods are stronger also when sawed in this way.

CHAPTER SEVENTEEN

EVERGREENS

THE trees that we have studied up to this time are *deciduous*; that is, they shed their leaves in the autumn. But in many parts of the United States and Canada *evergreens* are more common than the trees that lose their leaves with the coming of the cold months. Each type of tree is best suited for life under certain conditions, and whether evergreens or deciduous trees are more common in any given region depends on the prevailing conditions of soil and climate.

Definition of an evergreen. While any plant that remains green throughout the winter is an evergreen, and while in many parts of the United States we have broad-leaved evergreen trees and shrubs like the magnolia, holly, and rhododendron, yet we commonly mean by an evergreen a tree or shrub with needle-shaped, awl-shaped, or scaly leaves. The pine, spruce, cedar, and fir are trees that belong to this group. They do not, however, retain the same leaves as long as they live. Under a pine or cedar tree the ground may be covered with fallen leaves, but they fall a few at a time and not all in a single season or year.

The deciduous tree. In the spring a deciduous tree spreads out a vast number of broad, thin leaves to the light. All leaves give off water, and it is estimated that a large birch tree must draw from the earth 100 gallons of water each day to prevent its leaves from withering and drying in the hot sun. The delicate, thin leaves of such a tree cannot endure cold, and in winter it is possible for the roots of a tree to secure only

very small amounts of water from the frozen soil; so trees with broad, thin leaves drop them before the cold season comes. During the months when the air is warm and water is abundant they run a great food factory and store in their branches, stems, and roots the surplus food which they make. On this surplus they live through the winter, and from it they build in the spring their flowers, leaves, and young twigs. The working season of most deciduous trees is even shorter than we think, for the delicate leaves cannot appear until after the season of frost is over, and they fall from many trees as soon as the first frosts of autumn come.

On the other hand, the leaves on most evergreen trees are small, and they are tough and leathery so that they resist cold and drying. A tree of this kind does not have the great spread of leaf surface that a deciduous tree has. At no time can it manufacture food as rapidly as a deciduous tree does when it is in full leaf; yet the leaves of evergreens are able to build some food for the tree during the greater part of the year, whereas the trees that lose their leaves at the end of summer cannot add to their stock of nourishment until the following spring. In some locations the slower and steadier method of the evergreen succeeds better than the plan of rapid work for a shorter part of the year followed by the deciduous tree.

Where the deciduous and evergreen types succeed. In most parts of the temperate zone where the soil is deep and moist, as in rich river bottoms, and where the growing season is long and the air moist, the de-

ciduous tree grows better than the evergreen. The abundant water supply and the low rate of evaporation from the leaves enable it to support a great crown of leaves, and the long growing season allows it to keep these leaves for so long a time that in the course of a summer it can manufacture more food than an evergreen can, even though it keeps its leaves during the whole year.

The evergreen, on the other hand, succeeds where the water supply is not so great, where evaporation is more intense, or where the winters are long and cold. In sandy soils and on steep and rocky mountain slopes; where the air is dry; and in the far north, it is the prevailing type of tree. Its small, tough leaves demand only a small amount of water, and by working through a longer season they make more food for the tree than the leaves of a deciduous tree can produce in dry locations or during short summers. Do you think evergreens are not found in deep, moist soils because they will not grow in these locations, or because in such places the deciduous trees grow more rapidly and crowd them out?

In the moist tropics where there are no cold seasons the trees do not need to shed their leaves and are all evergreens. But these evergreens have broad leaves like our deciduous trees and differ in type from the evergreens of dry and cold regions. Just why the trees in many swamps are evergreens has not been fully explained, but one reason probably lies in the fact that under swamp conditions only a feeble root system can be developed.

Conifers. Most of our evergreens produce cones and hence are called *conifers* or cone bearers. The cone is the fruit. The seeds are protected by the scales of the cone but are not inclosed in an ovary. Pollen from other flowers falls directly upon the ovules. The pollen is produced in great abundance and is carried by the wind. If the tree is surrounded by others of the same species, its chance of receiving pollen for its many ovules is greater. For this reason evergreen trees are not often found scattered in small numbers over a large area. You might travel a hundred miles without seeing a pine, spruce, or hemlock, excepting such as have been planted,



FIG. 68. Cones from six different evergreens: (I) Blue spruce, (II) Norway spruce, (III) White spruce, (IV) Douglas fir, (V) Big Tree, (VI) Austrian pine.

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FIG. 69. Wood of arbor vitæ as seen through a microscope. The wood is light and, like that of other evergreens, is non-porous and uniform in texture.

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FIG. 70. Wood of the piñon, a species of western pine. In the pine there are resin ducts which appear as openings in the wood.

but when you come to one you will probably see near it many others of the same species.

The coniferous trees of the United States and Canada all belong to the pine family. Among lumbermen their wood is spoken of as "soft wood," although that of the Georgia pine and some other kinds is hard. The wood of deciduous trees is called "hardwood," although that of some kinds of deciduous trees is soft. In the four chapters that follow will be found descriptions of our most important conifers. The wood that is furnished by these trees is a most important source of



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FIG. 71. Paper leaving the mill for a metropolitan daily. The paper in this photograph represents about one half the amount used by the newspaper each day. Much paper is made from spruce and other evergreens.

lumber. It is fine grained and easily worked, is light, and for its weight strong, and shrinks evenly when it is dried. The habit which these trees have of growing in large numbers together is also valuable to the lumberman. It enables him to get out a large amount of lumber of the same kind at one time.

CHAPTER EIGHTEEN

CEDARS

High on a hill a goodly cedar grewe,
Of wondrous length and streight proportions,
That far abroad her daintie odors threwe.

SPENSER

IN our country the term *cedar* is applied to a number of trees that belong to different but closely related groups. They are noted for their fragrant and durable wood, which in most species has a reddish color. The famous cedar of Lebanon, which was so highly prized in the time of Solomon and is still venerated by the Arabs,



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FIG. 72. An eastern red cedar or juniper.

is a relative of our cedars. So is the Himalayan cedar, or deodar, which is venerated by the Hindus. Both of these cedars are evergreens and produce cones 4 inches or more in length. In Australia and in various tropical countries are different trees which on account of their scented wood are known as cedars, but they do not bear cones and are not related to the cedars of the United States.

Red cedar. The wood of the eastern red cedar, or juniper, is straight, fine grained, and easily whittled. It is used in making most of our lead pencils, and for



FIG. 73. A spray of juniper. The berries are an important source of food for birds in winter.

washing machines, ice-cream freezers, and wooden pails. Chests made of it are used for storing furs and woolen garments. Its odor, which is so agreeable to us, is generally thought to be repulsive to moths; but recent tests show that this is not really the case,—that the chests protect the garments by keeping the insects from

getting to them, and that woolen clothing is as safe in any tight chest as in one made of cedar wood.

When cedar trees were abundant, the wood was used for ties, fence posts, and the sills of houses, for it is remarkably durable. In damp places most kinds of wood decay in a few years, but cedar posts and sills often last 40 years or more. It is also used for the interior finish of houses.

Hardly any large red cedar trees remain, and in late years men have dug out, for the wood in them, the stumps of trees that fell to the ax more than half a century ago. The wood has sold for as much as a dollar a cubic foot. The sapwood is not red but quite light colored. Both sapwood and heartwood may often be seen in cedar chests. Cedar oil is distilled from the wood and leaves.

Unlike pines, spruces, and most other evergreens, the red cedar produces berries instead of cones; or we may say the scales of the tiny young cones become fleshy and the cone develops into a sort of berry. These bluish berries are eaten by various birds, which are not only fed by the tree but are also sheltered from the winter wind by the persistent foliage. This is a good reason for planting the tree.

The red cedar is easy to grow if the soil is not deficient in lime. If needed, air-slaked lime or ground limestone should be supplied when the trees are planted. In the wild state this tree may be found in nearly every section of the United States and in southern Canada, but there are many districts in which it does not grow. Formerly there were many trees exceeding 2 feet in diameter, but you are not likely to see such trees now, although you may see thousands of smaller ones. Red cedars are undesirable in the vicinity of apple or pear trees, for



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FIG. 74. White cedar or arborvitæ in a Minnesota swamp.

they harbor a parasitic fungus which spreads from them to these fruit trees.

The leaves of the red cedar are very small and are closely attached to the twigs on which they grow, but in the young seedlings the leaves are longer and stand out free from the stem as the leaves of an ordinary plant do. This stage is called the *juvenile form* of the tree. Scientists believe that in the early period of its development a young plant or animal resembles its ancestors; that the ancestors of the frog had a tail and lived in the water like a fish, and that in the tadpole stage the frog resembles this ancestor. Do you think the ancestor of the red cedar had free leaves or leaves closely applied to the stem?

Arbor vitæ. The arbor vitæ, or the "tree of life," is often called "white cedar." It is grown in hedges that are not only ornamental but also useful in protecting birds from the wind. It may be told from red cedar by



FIG. 75. A spray of arbor vitæ. The tree may be distinguished from the juniper by its flattened twigs and small cones.

its flat spray and its fruit, which is in the form of numerous small cones instead of bluish berries. Many telephone poles are trunks of arbor vitæ that grew in swamps in the Northern states or in Canada. For posts and ties this wood is valuable because it is durable in the ground.

Canoe cedar. From Alaska to northern California grows a species of *arbor vitæ* which is very large and beautiful, with the trunk sometimes attaining a diameter of 15 feet. This is known as *canoe cedar* and also as *western red cedar*. From it the Indians of the north-west coast build their lodges, carve their wonderful totem poles, and hollow out their great war canoes. From the fibers of the inner bark they make ropes, blankets, and thatches for their cabins. The principal uses of the wood are for shingles, cooperage, poles, and posts. It is light in weight, reddish brown in color, and has an aromatic odor and a spicy taste.

Why do plants have fleshy fruits? Why does the red cedar produce berries? Is it to provide food for the birds? Or does a tree have some purpose of its own that is served by a fleshy fruit? Perhaps you have seen young cedars come up along a fence row. If you can find out how they were planted there, you will understand the use of the fruit to the tree. Why do many fruits have bright colors?

CHAPTER NINETEEN

SEQUOIAS AND CYPRESS



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FIG. 76. Giant sequoia or Big Tree. The trees shown in the background are very tall pines and firs.

THE sequoias are named after Sequoyah, a Cherokee chief. They surpass all other trees in size, and only the eucalyptus trees of Australia equal or exceed them in height. There are two species of sequoia, the redwood of our Pacific coast and the Big Tree which is found only in a few groves in California. The cypress of our Southern states is the largest conifer in the eastern part of North America, but it is not so large as the giant sequoias of the West.

The redwood. The redwood grows only near the coast, where the air is kept moist by fogs from the ocean. It attains a height of from 200 to 340 feet. The wood is soft and light, and resembles some kinds of cedar in color, but it can be distin-

guished from cedar woods by the lack of any odor or taste. From the forests in California and southern Oregon redwood shingles are transported thousands of

miles. Forty thousand feet of lumber are often obtained from a single trunk. Probably you can get a sample of the wood by going to a lumber yard or to a house which is being covered with reddish-colored shingles.



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FIG. 77. A group of redwoods. Some of the trees shown in the photograph are more than 250 feet high.

The tree reproduces by sprouts that spring up around old trees.

The wood is especially valuable for use underground and where it is exposed to water. Redwood water pipe has been known to be serviceable after half a century of use. Water flows through wooden pipes with less friction than through iron pipes of the same size, is less likely to freeze in winter, and keeps cooler in summer. Before it is laid the redwood pipe is coated with asphaltum.

The Big Tree. The Big Trees of California were unknown to the white men until 1850, when a deer hunter came with astonishment amongst a group of them. They grow in the Sierra Nevada Mountains, 4000 to 8000 feet above the sea. They are larger than the redwood but not quite so tall; some are 320 feet high and 28 feet in diameter.

The Big Trees are indeed giants. Through the hollow in the base of one of them a road has been made, on which passengers can ride on a tallyho or in an automobile. In the eastern half of the United States, trees more than 120 feet in height are rarely found, and a tree 7 or 8 feet in diameter is accounted very large indeed.

As some of the groves of Big Trees are now national parks, these forest giants will be spared to excite the wonder and admiration of travelers for generations to come. Many of them are already more than 2000 years old and some probably more than 4000. How old were they when Columbus discovered America? What cities were built as long ago as 4000 years? Have any of these cities endured as long as these trees?



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FIG. 78. In a cypress swamp near Memphis, Tennessee.

The cones of this great tree are only 2 or 3 inches long. Although many of the seeds fail to germinate, the tree can be raised by planting the seeds, and thousands of seedlings are to be seen about the old trees, where lumbering has opened up the forest and exposed the soil to the sunlight. The Big Tree does not, like the redwood, reproduce by sprouts.

The bald cypress. In the Southern swamps grows a remarkable tree, the bald cypress, which may occasionally be seen in cultivation in the North. As it is related to the cedars and pines, we should expect to find it retaining its leaves throughout the year, but it loses them, or becomes bald, in winter. At other seasons its delicate green foliage makes it a beautiful tree. It usually grows where its roots are covered with water. Most trees would die if their roots were under water for several months, but it is in swamps, where its roots are submerged, that the cypress usually grows. It has curious growths, called "knees," which extend from the roots up into the air.

Cypress trees surpass in size all others in the eastern half of America, with the possible exception of the sycamore, tulip tree, and chestnut. Some have been found 150 feet tall, and some have trunks 12 feet in diameter. They furnish a large amount of valuable lumber, which is soft, light, and with a straight grain. Where most kinds of timber would soon rot, cypress endures. It is extensively used for water tanks, silos, greenhouses, boats, ties, and for shingles, sash, and other parts of buildings exposed to the weather. Many country houses in the South are roofed with short boards split from cypress.



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FIG. 79. Monterey cypress in Monterey County, California. This tree is a western relative of the bald or southern cypress.

CHAPTER TWENTY

SPRUCE AND FIR

I remember, I remember,
The fir trees dark and high;
I used to think their slender tops
Were close against the sky.

Hood

SPRUCE and fir resemble pines in having the branches arranged in whorls; that is, several branches grow in a circle at the same level. They differ from pines in having the leaves scattered on the branchlets instead of being arranged in clusters. They grow as forest trees in the northern parts of the United States and in our Western mountains, but spruce trees have been extensively planted in cemeteries and near dwellings in other parts of the country. Besides affording dense shade, these trees are ornamental and break the force of the wind. Many thousands of young spruce and fir trees are sold each year as Christmas trees. At the holiday season children who live hundreds of miles from the forests where these trees grow become familiar with them.

Kinds of spruce. The blue spruce from Colorado has foliage of a bluish color. From the main branches the longer branchlets droop. When not trimmed, the lowest branches are near the ground and the tree is shaped like a cone.

The Norway spruce sometimes grows two or three feet in one season and is the species most commonly found in cultivation. Its branches extend out almost horizontally from the trunk, curving up a little toward the ends. By its larger cones it is readily distinguished from the white, red, and black spruces, all of which grow

in Canada and the Northern states. Other large species of spruce are found in the mountains of the West.

The cones and seeds of the spruce.

The cones of both spruces and firs have much thinner scales than the cones of the pines. The cones of the spruce are drooping. In what part of the tree do they hang in greatest numbers? If you can get a full-grown cone which has not yet lost its seed, take it home or to the schoolroom. After a time the scales will spread apart so that the winged seeds can drop out. When thrown in the air, do the seeds fall straight down? Why?

The wood of the spruce. In Europe masts and spars are often made from the tall, straight trunks of the Norway spruce. On account of its uniform grain the wood of this and other species of spruce is used for the sounding boards of musical instruments. The lumber is soft, white, and straight grained and, in proportion to its weight, has great strength. It is used for many purposes, and of recent years has come into great promi-



R. E. Horsey

FIG. 80. Blue spruce in Highland Park, Rochester, New York.

nence because of the large amounts of it needed for the manufacture of airplanes. Much of the paper used in books and newspapers is made of spruce wood.

Firs. Different species of pine and spruce are often called "firs"; but the name "fir" is properly applied to evergreens that resemble spruces in general appearance, but have erect instead of drooping cones, and leaves that are not jointed at the base. The only true fir native to the northeastern part of the United States is the balsam fir, which grows also over much of Canada and in the mountains as far south as Virginia.

The leaves on this fir are blunt and flat, and not four-sided like those of a spruce. On the horizontal branches they appear to be two-ranked instead of standing out all

around the branch, as do the leaves of the spruce. Persons camping where fir trees are growing often make a bed of the boughs; but they avoid the spruce because its leaves (needles) are sharp and stand out all around the stem. The leaves of the fir last a long time; if undisturbed, they persist on the tree for 8 years.



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FIG. 81. Alpine fir, Blackfoot National Forest, Montana.

Young balsam firs and Norway spruces

look so much alike that it is difficult to tell them apart at a distance. But the bark of the fir, except on old trunks, is quite smooth, and on its surface are numerous blisters of a resinous substance called "balsam." These blisters distinguish the true firs from all other trees. The balsam which is obtained from the balsam fir is called "Canada balsam." It is used in fixing delicate specimens on glass slides for examination through a compound microscope. "Pine pillows," filled with the leaves of this tree, keep their fragrance for 2 or 3 years.

In the mountains of Tennessee, North Carolina, and Virginia a different species called "Fraser's fir" is found, and other large species of fir from which valuable lumber is obtained grow in the mountains of our Western states. Although abundant in the woods in cold regions, firs are not seen in cultivation as often as spruces.

The Douglas fir. The Douglas fir is also called "Douglas spruce," though it is neither a fir nor a spruce, but only a close relative of these trees. It is one of the most valuable trees of the whole country. It is widely distributed in the mountains of the West



R. E. Horsey

FIG. 82. Douglas fir, Highland Park, Rochester, New York.



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FIG. 83. Red fir forest on Mount Shasta
at an elevation of 5000 feet.

and along the coast of Oregon, Washington, and British Columbia, where it grows taller than any tree in the Eastern forests. In the interior of the continent it is not a remarkably large tree, but on the Pacific coast it frequently exceeds 250 feet in height and 10 feet in diameter. Ladders used by fire departments are made from its wood, for it is light, straight grained, and free from knots. Large quantities of this wood are used for building and other purposes. Many masts and flag-poles are made of it.

When the Douglas fir grows in open places, the lowest branches, like those of various spruces, touch the ground. It grows rapidly and is a handsome tree. In the moist, mild atmosphere of England it was found to thrive as soon as introduced, but in our Northeastern states the climate is too severe for it. It has been found recently that stock from the mountains of Colorado is perfectly hardy, so that the tree may now be successfully planted in various parts of this country.

CHAPTER TWENTY-ONE

THE PINE

Like two cathedral towers these stately pines
Uplift their fretted summits tipped with cones;
The arch beneath them is not built with stones,
Not Art but Nature traced these lovely lines,
And carved this graceful arabesque of vines.

LONGFELLOW

MORE of our lumber comes from the pine than from any other one tree, yet many people do not know a pine when they see one. Some think that all evergreens are pines.

Pine trees have slender leaves, called "needles," growing in clusters. When young, each cluster has a sheath of papery scales at its base. The cone scales of the pine are thicker than those of spruce or fir. Pines, like spruces and most other conifers, are excurrent trees. Many species have trunks that extend to a height of more than 100 feet, and some species to a height of more than 200 feet. They often grow in *pure stands*; that is, to the exclusion of other kinds of trees.

Products of pine trees. Tar, turpentine, and rosin are obtained from several species of pine. These materials have long been called "naval stores," but they are now used more extensively on land than in connection with ships. Pieces of pine stumps and roots are heated in retorts, ovens, or kilns, and the turpentine thus driven off as a vapor is condensed by cooling it and afterwards separated from the acids, wood alcohol, and other products that come from wood when it is heated without air. Tar requires more heat to change it to



U. S. Forest Service

FIG. 84. Long-leaf pine forest near Ocilla, Georgia. Resin is being collected from the trees.

vapor, so that it collects in another part of the distilling apparatus. What is pine tar used for? What other kind of tar is there and how is it used?

When a small cavity is made in the trunk of a Georgia pine or of a western yellow pine, crude turpentine flows out. By distillation in large copper stills, oil or spirit of turpentine is derived from this. Rosin is left in the still. This is used in making the cheaper kinds of soap and varnish, and also in sealing wax and shoemaker's wax. What other uses has rosin? Turpentine is used largely in varnish and paint. What other uses has it?

Most frame houses are built chiefly of pine. Can

you name other uses for the wood? What are the properties of the wood? How do these properties adapt it to its various uses? Do pines furnish any food? What other uses have pine trees besides those already mentioned?

Species of pines. In the United States there are about thirty-six species of pines growing wild. The white pine formerly grew abundantly in parts of the Northern states from Maine to Minnesota and in southern Canada. It furnished

a vast amount of good lumber, but the supply is now nearly exhausted, so that white pine of good grade brings a high price. Southern yellow pine has taken its place for many uses. It is a harder and heavier wood than white pine, and contains more resin, but it is likely to split along the annual rings when it is nailed. Test the cleavability of a piece of yellow pine by driving a nail through it near the end.

In California, the sugar pine grows 200 feet tall and produces cones that may be 18 inches or more in length.



U. S. Forest Service

FIG. 85. White pine trees about 120 years old, St. Louis County, Minnesota. The trees are still growing in height.

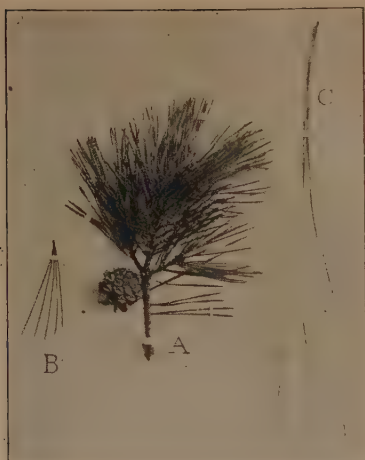


FIG. 86. Spray of Scotch pine, showing leaves and cone (A). Leaves of the white pine are shown at the left (B) and of the Georgia or long-leaf pine at the right (C).

Its seed or nut, the size of a navy bean, is edible, as are the seeds of several smaller species of pine, called "piñons," that grow in the Southwest. Another important pine is the western yellow pine, which is a valuable source of both lumber and turpentine.

Cones of the pine.

By comparing the cones of such pines as grow in your vicinity you will find differences in form and size. The

Scotch pine, which is

often planted in this country, has cones about 2 inches long, while the cones of the white pine are usually from 4 to 6 inches in length and may reach a length of 11 inches. The cones of pines require 2 years for their development, while those of the spruce and fir require but 1 year. When the winged seeds at the base of the scales are mature, the scales spread apart enough to allow the seeds to fall out and be borne away by the wind. The seeds of these and other evergreens are not inclosed in an ovary, but grow at the base of the cone scales. See if you can find them.

Pine needles. The needles of the valuable Georgia pine, which is one species of yellow pine, are sometimes

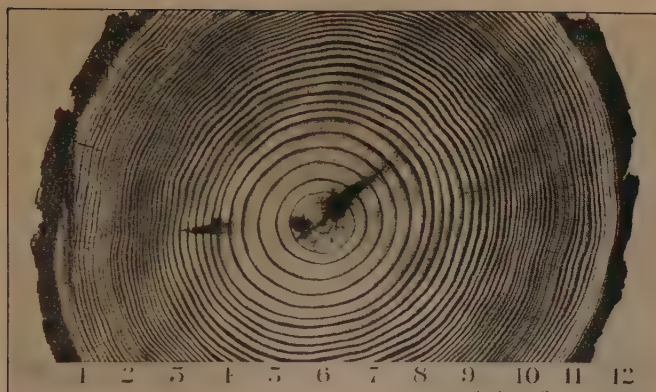


FIG. 87. Section from a 52-year-old short-leaf pine. The tree grew in a forest near Glenville, Arkansas, and was of average size.

as much as 18 inches long and grow in clusters of three; those of the white pine are very slender, but shorter, and grow in fives; those of the Scotch pine are still shorter and are in twos, as are those of many of the native species.

Examine the leaves of a young pine seedling. Are they needle leaves or ordinary leaves, and are they on the ends of dwarf branches or attached to the sides of the stem? What inference can you draw as to the leaves of the ancestor of the pine?

Pollen of the pine. In spring the yellow pollen from the pine trees falls in such quantity that it is sometimes spoken of as a shower of sulfur. For seed production some of this pollen must fall on the young cones. You can see an advantage to these trees from growing in pure stands. Will a cornstalk growing by itself produce much grain?

CHAPTER TWENTY-TWO

TRANSPLANTING TREES

When we plant a tree we are doing what we can to make our planet a more wholesome and happier dwelling place for those who come after us, if not for ourselves.

OLIVER WENDELL HOLMES

OUR appreciation of the beauty and usefulness of trees causes millions of them to be planted in our country every year. As a rule people do not attempt to raise them from the seed, but get them from a nursery or from the woods. While a tree can be moved without difficulty if the work is properly done, it should always be remembered that transplanting is a very severe operation; for having its roots dug out of the soil and many thousands of the little rootlets through which it draws its water and food materials torn away, forces the tree to begin a new life. Some directions for transplanting will be useful, therefore, and when a tree is to be moved these should always be most carefully carried out.

Time for transplanting. Most kinds of trees may be transplanted in either spring or fall. If trees are moved in the spring, it should be done before the buds open and when rains are expected. October and November, except in a dry season, are the best fall months for transplanting deciduous trees. Of course, such a tree should not be lifted when in full leaf; we could not expect the roots of a newly transplanted tree to supply with water a great number of leaves.

For evergreens, August is considered by some authorities to be the best month, if the weather is dry, but they may be transplanted at any time after this until spring. If trees are transplanted in winter, a ball of

earth should be left attached to their roots. For most evergreens the early spring, before vegetation starts, is probably the best time to transplant.

Care of the roots. Young trees from a nursery, having already been transplanted once or twice, have the root system developed close to the stem and therefore can be made to grow in a new location more easily than trees from the woods. In getting trees from the woods, select good specimens of small size, which can be dug up and transported without cutting away as much of the branches and roots as would be necessary with larger trees. If the tree is so large that many roots are cut off in getting it out of the ground, then the crown should be trimmed also, for otherwise the impaired root system cannot supply water for all the leaves that come out when growth is renewed.

Some earth should be



FIG. 88. Tip of a young root (magnified). If the roots of a tree are allowed to dry for even a few minutes, the root hairs and small roots are killed.

left on the roots, for if it is all shaken off, the delicate root hairs, by means of which the roots absorb water, will come off with it. *The roots should not be exposed to the air*, as this is fatal to the delicate rootlets and root hairs. Do not forget to give attention to this point. Wrap the roots in old bags or large sheets of paper, moisten them if they are not covered by earth, and get them into the ground as soon as possible.

Digging the hole for the tree. When planting a tree in a lawn, spread a piece of canvas or burlap or use a board platform upon which to throw the dirt from the hole. Dig the hole large enough for the roots to spread out naturally. Make it larger at the bottom than at the top, to prevent too much water from collecting about the roots and also to assist in holding the tree firm. Avoid puddling the edges of the hole with the spade. In very heavy soils it is advisable to break up the subsoil with dynamite or giant powder. Do not dig the hole long before the tree is ready to be set into it; the soil that is packed about the roots should not be allowed to dry.

Planting the tree. Lay the roots out naturally, and with a sharp knife cut off all broken or bruised parts. *Plant the tree no deeper than it stood in the nursery row.* Probably more trees are lost from failure to comply with this rule than from any other cause. The right depth can easily be determined by the dirt line shown at the bottom of the bole. Good, fertile soil must be used about the roots, but no manure should be placed in direct contact with them. If the tree is to be planted in impoverished ground, enough good loam should be provided to fill the hole.

Be sure to press the earth firmly, especially around the bole, so that every particle of the earth is well compacted about the roots. The roots must draw their water from the soil, and if there are air spaces between them and the soil particles, they will not be able to do this. A tamping stick or the shoe may be used until all but 2 or 3 inches of the hole is filled, when a liberal watering should be given. This will assist in settling the soil and moistening the roots. When the water has settled into the soil, fill in the remainder of the soil loosely and make it level. Avoid piling the soil up around the trunk of the tree.

Cultivating and watering. After the first watering, occasional cultivation of the soil around the tree is useful, especially in dry seasons. If the season is very dry, occasional waterings will be of benefit, but a great many young trees are lost by overwatering. When water is needed, a thorough wetting of the soil at intervals of a week or two is better than giving a little water more frequently. Loosen the surface of the soil when it begins to dry after watering. A mulch of compost or stable manure helps to retain the moisture and hence is of great benefit. A cultivated area 3 to 6 feet in diameter should be maintained about the base of the tree. The cultivation need be only occasional, if the area is covered with a mulch.

Trimming and supporting. Trim off with a sharp pruning knife all broken branches, and also two thirds of the previous year's growth. Unless you do this the disturbed and shortened roots cannot at first supply enough water for all the leaves that will appear. It is

not always best to trim the central stem or leader, as a forked tree may be the result. Hardwood trees, like the oak and beech, should not have the central stem trimmed. Evergreens should not be pruned.

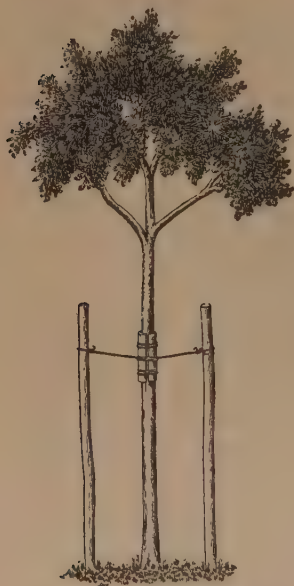


FIG. 89. A transplanted tree should be supported until the new roots have taken hold in the soil.

If the soil does not pack well or if a large tree is to be planted in an exposed place, wire supports should be provided. Chafing of the tree should be prevented by the use of burlap or pieces of old garden hose through which the wire is run before being fastened to the tree.

Transplanting large trees.

If there is reason for transplanting a tree 6 or 8 inches in diameter, it is best to prepare it for transplanting a year in advance of the actual operation. This may be done by trenching around at a distance of 3 or 4 feet from the trunk and filling the trench with loose earth and manure. This filling will keep out frost, and the tree will develop a sufficient system of feeding roots within the earth that must be taken with it, so that it is more likely to survive than if it were taken up without this preparation. Trees of this diameter have been successfully transplanted while the ground was still frozen.

CHAPTER TWENTY-THREE

THE CARE OF TREES

In all the range of Nature there is no object which so commonly inspires the tenderer and finer emotions, and which would leave the earth so bare of loveliness if it were to be removed. — L. H. BAILEY

GOOD trees are highly prized by those who know their worth, but like other valuable things they require care. Furthermore, it is true of trees, as of persons, that it is much better to keep them in good condition than to allow their health to be impaired and then attempt to restore it. An ounce of prevention is worth a pound of cure in tree growing as well as in other activities of life.

The needs of trees. Trees need light, air, water, and suitable soil. The part above ground will get air enough, but not always enough light. A compact clay soil does not admit air enough to the roots, nor does a soil continually saturated with water. The water level should not be lowered very much at one time by ditching, for the tree may suffer from the abrupt change. Likewise, if grading demands filling in around the tree, it is best to use materials like sand and gravel that will not exclude air, and to avoid raising the level of the ground more than 8 or 10 inches in one year. Sometimes a well is left around the trunk of the tree to admit air, the top being covered with a grating. In the New York Zoölogical Garden many animal cages with concrete floors were built around large trees. The floors were raised a foot or more above the ground, and circular openings around the trunk admitted air to the roots while iron guards protected the trees from injury by the animals.

Except in dry seasons or in dry regions, a tree will always get enough water from the rain, if the soil around it is in proper condition. If its roots are covered by a pavement or if it stands on the edge of a terrace or on a lawn where the grass uses much of the water, the tree may suffer. Water is not so much needed close to the bole of the tree as out where it drains off the leaves, for the absorbing roots are at some distance from the trunk. A mulch of dead leaves, peat humus, well-rotted stable manure, or garden mold helps to prevent loss of water by evaporation from the surface of the compact soil. The mulch should not be deep. Half an inch to an inch is sufficient. Such a mulch is useful also in supplying nitrogen and other food material to the tree. To furnish potassium, hardwood ashes are useful, 10 pounds for 100 square feet of soil. If the earth around the roots is a heavy clay, it may be improved by working in some sand or garden mold, or some gypsum, marl, or slaked lime that does not contain much magnesium.



FIG. 90. The limb was cut off close to the trunk, and the wound is healing over.

If fallen leaves are not permitted to remain on the ground, an artificial fertilizer may be needed to supply the tree with nourishment. This should be applied in the spring just as the buds are opening, not close to the trunk, but under the tips of the branches. A tree that spreads over an area 30 feet in diameter may be given a mixture of 1 pound of nitrate of soda, 6 pounds of cottonseed meal, 2 pounds of acid phosphate, and 2 pounds of muriate of potash.

Pruning. The beauty of trees is often spoiled by bad pruning. Many trees require no pruning, unless some accident befalls them. Pruning of shade trees should be done with a view to making the tree as symmetrical as possible. A well-grown tree is a thing of great beauty even in winter, and in summer the grace with which it carries its foliage depends on the symmetry of its branches. Rather than keep a tree that is badly pruned, take it out



FIG. 91. The limb was cut at a distance from the trunk, and through the dead stump decay has entered the trunk of the tree.

and plant a good young tree in its place. Cutting off much of the top of the tree usually spoils its appearance.

Dead or deformed limbs should be removed. If they remain long on the tree, fungi of decay get into them and grow down into the trunk. *Limbs should not be cut off several inches from the trunk, but close to it, so as to permit the bark to grow over the wound.* The cut surface is often treated with a coat of paint or coal tar to prevent fungi from getting access to the wood, but recent tests show that this is not always necessary; small wounds heal more quickly without any dressing. If the wound is as much as 2 inches in diameter or if the wood is not perfectly sound, gas tar should be applied. If the limb is heavy there is danger of its pulling off some bark from the trunk just beneath where it is attached, before the saw has gone all the way through. To prevent this, the limb should first be sawed

partly through from beneath, 8 or 10 inches from the trunk.

It is better to prune a little every year than to prune severely at one time. The main limbs and the branches attached directly to them should be left, and pruning limited to the third and fourth divisions in the branching. If shade trees have branches so low as to interfere with people or vehicles passing under them or with illumination by street lights, it is usually best to trim off the smaller branches rather than larger ones. When a tree is growing the layers of lower branches should be removed, not all at one time, but at intervals of a year or more, until the trunk has become clear to the desired height.

Pruning should be done when there are no leaves on the tree. The leaves are the tree's food factory, and if the pruning is done while the tree is in foliage, both the factory and the reserve food supply in the leaves will be lost. However, the wounds heal more quickly if the pruning is done after growth begins in the spring than when the pruning is done earlier, while the tree is dormant. In case it becomes necessary to cut a large root of a tree, some of the crown on the same side should be cut away also, for otherwise the remaining roots will be unable to supply enough water for the leaves.

Spraying. The spraying of trees receives much more attention now than formerly. It is of great importance for both fruit and shade trees. The agricultural experiment stations issue bulletins that give formulæ for preparing the spraying mixtures and methods of applying them. In many cases it is necessary to spray more

than once a year in order to kill insects or fungi that infest the tree at different seasons. Some sprays would injure the foliage and must be applied before the buds open.

The direction of the wind must be considered when spraying, and for thorough work the spraying should be repeated after the wind shifts, so as to get the poison on both sides of the leaves. If a heavy shower falls shortly after the trees have been sprayed, the work must be done again. Wet seasons sometimes necessitate spraying several times. Thoroughness should be the watchword in spraying; neglect of thorough spraying is like attempting to put out a fire by throwing a great deal of water everywhere except upon one little neglected spot, from which it may spread into a conflagration.

Assistance of birds in protecting trees. In caring for trees the assistance of the birds should not be despised, for they are incessantly searching for insect pests. Without their help the insect enemies would be hard to control. The birds should be made welcome and the trees and grounds made as safe and inviting for them as possible. In another part of this book suggestions for attracting birds will be found.

Name some animals that injure trees with their teeth. How would you prevent this? In what ways are trees likely to be damaged by wires or cables? Have you known of trees needlessly injured in still other ways? Was the injury due to carelessness, ignorance, or some other cause?

Tree surgery. Tree surgery is practiced by men who have had training in this art. As dentists fill cavities in teeth with gold or amalgam, these men fill cavities

*N. Y. State Conservation Commission*

FIG. 92. Tree surgery.

*N. Y. State Conservation Commission*

FIG. 93. The surgeon at work.

in trees with a mixture of two parts of sand and one part of Portland cement. For large cavities, broken stone and brick are used besides the sand and cement. In place of these materials a mixture of sawdust and asphaltum is now recommended. It is not so rigid as the cement. For cavities in swaying branches three or four times as much sawdust as asphaltum is used; for cavities in trunks the mixture is made in the proportion of five or six parts sawdust and one part asphaltum. The filling is not brought up flush with the outside of the

bark of the tree, but stops at a depth equal to the thickness of the bark so that the healing callus may overgrow the filling. Filling a large cavity in the trunk tends to prevent the tree from being blown over by the wind. The removal of dead wood before the cavity is filled and the exclusion of water by the filling tend to prevent further decay. Cavities caused by decay in the trunk where a big limb has broken off from it or has been improperly pruned are treated like hollows at the base of the trunk, to arrest the spreading of the disease.



FIG. 94. Supporting a tree at the fork.

Tree doctors also fasten together with chains or rods large limbs that are in danger of splitting apart, fastening the ends of the chains, not to bands, which would in time cut through the bark and into the wood, but to bolts passed through the branches after boring holes through them. Tree surgery requires judgment and skill, and the owner of trees needing repair must be cautious to avoid employing an impostor, who will do more harm than good. If the injury that calls for attention is merely abrasion of the bark, the owner of the tree should cut away with a sharp knife all loose, ragged, or injured bark as far as the injury extends. If left on the tree, this bark would shelter insects and fungus spores which in time would injure the tree. The exposed wood, unless its area is small, should be painted with refined gas tar.

Protecting trees from horses, wagons, wires, linemen, and other causes of injury may save expensive tree-doctor bills, just as proper care of the human mechanism usually keeps it healthy without the aid of a physician.



FIG. 95. Trees should be protected from injury by animals.

Forestry. If the destruction of the forests of this country should continue in the future at the same rapid rate as in the past, you might live to see the day when lumber would be very scarce. Preservation of forests is desirable, not only for the lumber and other useful products they afford us, but also to prevent the washing away of soil and to regulate the flow of streams. On the hillsides in China much land has been ruined by torrents of water that might have been prevented if the trees at the higher levels had been preserved. In that country many thousands of people are drowned by floods, and other thousands perish from famine caused by the floods washing away the soil or covering it beneath deposits of gravel or coarse sand. Forests cause snows to melt more gradually and check the flow of water at times of heavy rainfall, and so tend to prevent floods. In dry weather the rivers are still fed by innumerable streams that bring water from the ground which is covered by forests. Consequently the rivers that drain

a region where there are forests often carry water enough to furnish power for mills and power houses or even for navigation throughout the entire year.

The United States Government has a Forest Service which seeks to prevent forest fires and wasteful lumbering on government lands. Most of the national forest reserves are in mountainous districts. Some of them afford pasture for large herds of cattle or sheep, others are useful as game preserves. The cutting of trees that are ready to be harvested is permitted, but under such restrictions as to prevent the forest from being destroyed. The promising young trees in a forest are saved, and in time they will furnish a supply of good lumber.

In the prairie region of the West many trees have been planted by railroad companies and private owners in order to supply material for ties, posts, telephone poles, and other uses, and setting out rough lands in trees is becoming an increasingly common practice in the older states. Several universities now have flourishing schools of forestry, where young men are trained in the scientific management of forests, and some states and cities own forests and are employing foresters to manage them so that they may be used continuously to meet the needs of the people.

“The city of Zurich in Switzerland has owned a forest for one thousand years. It has been so carefully regulated that it has furnished a definite amount of timber each year for six hundred years and is today in better condition than ever before. The Metropolitan Park System of Boston is the best illustration in this

country of a chain of parks and timber reservations belonging to a city, and devoted to the recreation and uplifting of its whole population. These parks are a refuge for wild flowers that agriculture has exterminated, and for wild birds that towns have driven out. They are the precious heritage of the people and should never pass out of their hands." — Julia E. Rogers, *The Tree Book*.

APPENDIX

KEY FOR THE IDENTIFICATION OF SOME COMMON HARDWOODS ¹

In order to use the following key as a means of identifying woods whose names you do not know, you should first acquire some practice in tracing to the right place in the key specimens of wood of which you already know the names. Identification will be easier if your specimen includes both heartwood and sapwood. It should be clean and smooth but not sandpapered. With a *very sharp* knife cut across the grain so that you can examine the end of a piece. A good section, half an inch square, is large enough. Instructive, small, thin sections may be made with a penknife or razor, and when placed on a piece of thin glass, moistened, and covered with another piece of glass, they may be examined by holding them toward the light.

A lens (magnifying glass), although not essential, is a great help in seeing the pores and pith rays. In using it be careful to avoid shading the specimen you are examining; unless the light is good, the glass will be of little use. Slightly moistening the surface of the wood may bring out its features more plainly. The illustrations will help you to understand the key.

The plan of the key. In the key the woods are divided into two groups, — ring-porous woods, which are placed under the Roman numeral I, and diffuse-porous woods, which are placed under the Roman numeral II. Then each of these groups is subdivided into smaller groups which are placed under capital letters (*A, B, etc.*). If necessary, each division under a capital letter is again divided under Arabic

¹ A key for the identification of a larger number of American woods may be obtained by sending to the Superintendent of Public Documents, Washington, D. C., for a *Guidebook for the Identification of Woods Used for Ties and Timbers*, issued by the United States Forest Service.

figures (1, 2, etc.), and, finally, the groups under some of the figures are split up into divisions with small letters (*a*, *b*, etc.).

How to use the key. Suppose you have a piece of wood and have no idea what it is. The first thing to decide is whether it is a ring-porous or a diffuse-porous wood. Look at your specimen to decide this point. If it is ring-porous, it belongs under I; if it is diffuse-porous, it belongs under II.

If you find it is diffuse-porous, the next question to decide is whether it belongs under *A*, *B*, *C*, or *D* of the diffuse-porous woods. Read the description of *A* first, and if your specimen does not agree with it, pass on to *B*, and then if necessary to *C* and *D*. If it does not fit under *A*, it will not fit in any of the smaller groups under *A*; so do not waste time on these but pass at once to *B*, *C*, or *D*.

Suppose now that the pores in your specimen are small and evenly distributed and you decide it belongs under *C*. The next step is to see whether it belongs under 1, 2, or 3. If the pith rays are fine, but yet visible without a lens, your wood belongs under 2.

The final step now is to determine whether your specimen belongs under *a*, *b*, *c*, *d*, or *e*. Let us suppose it is hard and reddish in color. These characters will then identify it as maple.

In case you think you already know the kind of wood you have, you can use the key backward to see whether you have the correct name for your specimen. For example, if you have a piece of wood that some one has told you is catalpa, you can find the name in the key and see if the description agrees with what you find by examining your specimen. If your specimen lacks the pith, that feature may be neglected; but to be reasonably sure that it is catalpa you should see that it agrees with I, with *A*, and with 1 above the description of catalpa, but not with *a* or *b* under 1.



U. S. Forest Service

FIG. 96. White ash.



U. S. Forest Service

FIG. 97. White elm.

I. RING-POROUS WOODS: PORES COLLECTED IN THE SPRINGWOOD IN RINGS WHICH ALTERNATE WITH LAYERS OF DENSER SUMMERWOOD, MAKING THE ANNUAL RINGS DISTINCT.

A. Pores in the summerwood very small, scattered or in groups.

i. Pith rays very fine, scarcely distinct.

- a. Wood rather heavy and hard; not yellow; few pores in the summerwood . . . **ASH**
- b. Wood very heavy and hard; heartwood golden brown with reddish brown streaks; yellowish color imparted in a few minutes to a wet rag or blotter . . . **OSAGE ORANGE**
- c. Wood light and soft; straight-grained; heartwood grayish brown; pith usually 3-sided **CATALPA**



U. S. Forest Service

FIG. 98. White oak.



U. S. Forest Service

FIG. 99. Red oak.

2. *Pith rays fine but distinct.*

- a. Heartwood reddish brown; sapwood rarely over $\frac{1}{2}$ inch wide; wood light and has a peculiar odor and spicy taste when freshly cut

SASSAFRAS

- b. Heartwood russet brown without reddish brown streaks, sometimes with a tinge of green; wood very heavy and hard . BLACK LOCUST

- c. Heartwood light orange-brown; sapwood yellowish; wood not so heavy as locust

RED MULBERRY

- d. Heartwood cherry-red; pith usually over 0.2 inch in diameter . KENTUCKY COFFEETREE

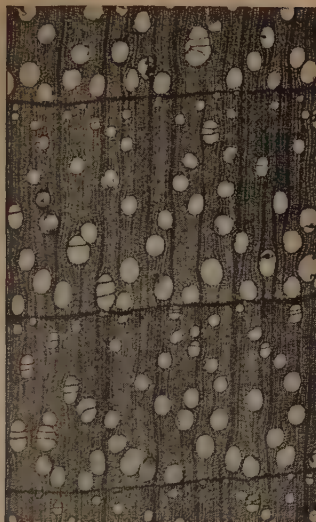
3. *Pith rays fine but conspicuous even without a lens.*

- a. Heartwood red; sapwood pale lemon, usually wider than in the coffeetree; pith usually under 0.15 inch in diameter HONEY LOCUST



U. S. Forest Service

FIG. 100. Water hickory.



U. S. Forest Service

FIG. 101. Black walnut.

B. Pores of summerwood small, in concentric wavy lines.

1. Wood moderately heavy; tough; heartwood reddish brown or light brown ELM

C. Pores of summerwood arranged in wavy or branching radial lines.

1. Pith rays hardly visible; wood moderately light and straight-grained; sapwood narrow; heartwood grayish brown CHESTNUT

2. Pith rays conspicuous; wood hard and heavy
OAK

- a. Pores in summerwood very small and numerous; heartwood brown, without reddish tinge; larger rays when seen in radial section from $\frac{1}{2}$ inch to 4 inches in height WHITE-OAK GROUP



U. S. Forest Service

FIG. 102. Sycamore. The black lines are pith rays, which are very prominent in this wood.



U. S. Forest Service

FIG. 103. Sugar maple. The wood is hard and because of its even texture is excellent for flooring.

- b. Pores in summerwood larger and not so numerous; heartwood brown, with reddish tinge, especially in vicinity of knots; rays averaging somewhat less in height than in white-oak group

RED-OAK GROUP

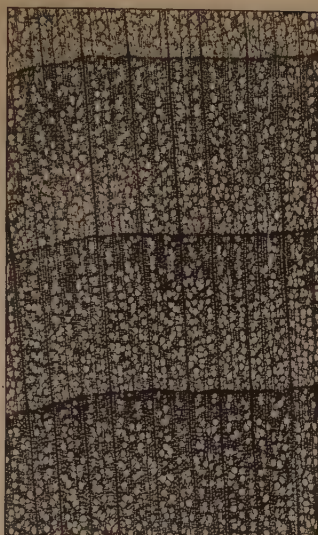
D. Pores plainly visible without lens in springwood; large in summerwood also, but somewhat smaller than those of springwood.

- 1. Wood very heavy and exceedingly tough; heartwood light reddish brown; fine lines of parenchyma cells in the wood running parallel with the annual rings HICKORY



U. S. Forest Service

FIG. 104. Yellow poplar.



U. S. Forest Service

FIG. 105. Basswood.

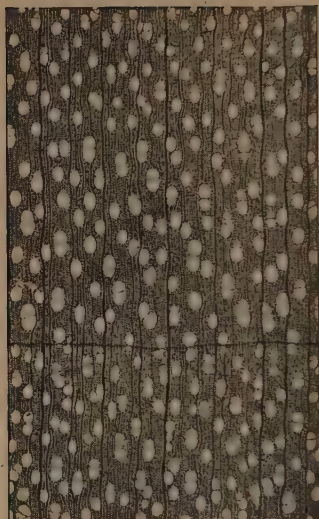
II. DIFFUSE-POROUS WOODS: PORES SCATTERED THROUGH BOTH SPRINGWOOD AND SUMMERWOOD.

A. Pores varying in size from large to minute ; largest in springwood, sometimes giving thereby the appearance of a ring-porous arrangement ; pith rays too fine to be distinct without a lens.

1. Wood rather heavy and hard ; heartwood chocolate-brown BLACK WALNUT
2. Wood light and soft ; heartwood light reddish brown ; without characteristic odor BUTTERNUT

B. Pores all minute and indistinct ; most numerous in the springwood.

1. Pith rays fine but distinct ; wood hard, heavy, and strong ; annual rings clearly defined ; heartwood reddish ; sapwood narrow BLACK CHERRY



U. S. Forest Service

FIG. 126. River birch.



U. S. Forest Service

FIG. 107. Cottonwood.

C. Pores minute or indistinct, evenly distributed.

1. Broad pith rays present.

- a. Pith rays numerous and crowded, and all or most of them broad; wood whitish or light brown; springwood not distinct from summerwood of the same year; moderately heavy; cross-grained and difficult to split SYCAMORE
- b. Pith rays not crowded and only part of them broad; summerwood distinct from springwood; wood heavy and hard; white, reddish white, or reddish BEECH

2. Pith rays all small but distinct without a magnifier.

- a. Wood hard; color reddish white; sapwood wide MAPLE
- b. Wood hard; white; sapwood wide HOLLY

- c.* Wood soft and light; pores not visible without a lens; crowded and occupying nearly all the space between pith rays; sapwood usually much more than 1 inch wide; color yellowish white, often with a greenish tinge in heartwood; annual rings clearly defined

TULIP ("YELLOW POPLAR")

- d.* Wood rather heavy but soft; cross-grained and tough; sapwood grayish; heartwood dingy reddish brown; annual rings not distinct even with a lens RED GUM

- e.* Wood soft, light, straight-grained; heartwood creamy brown with occasional darker streaks; sapwood creamy white, wide, and not sharply defined from the heartwood; pores small but distinct with lens; not crowded, occupying less than one half the space between pith rays, and ordinarily decreasing in number and size toward the outer portion of each annual ring BASSWOOD

- 3. Pith rays scarcely distinct without a lens, yet if viewed with a magnifier plainly visible. Sapwood whitish; heartwood reddish BIRCH*

D. Pores in springwood usually visible without a lens; pith rays not visible or else indistinct, even if viewed with a magnifier.

- 1. Wood very soft and light; white or in shades of brown; usually with a silky luster; sapwood not clearly defined, but passing gradually into heartwood . . COTTONWOOD*

A LIST OF BOOKS ON TREES

- Apgar, Austin C. *Trees of the Northern United States*. 212 pages. American Book Company, New York. Useful for identification of both wild and cultivated species.
- Hough, Romeyn Beck. *Handbook of the Trees of the Northern United States and Canada East of the Rocky Mountains*. Published by the author, Lowville, New York. 470 pages, profusely illustrated. A very useful book.
- Howard, John R. *The Best Poems on Nature*. 248 pages. Thomas Y. Crowell Company, New York. An attractive collection of nature verse of high literary order; 24 pages are devoted to a section on "Tree and Forest."
- Keeler, Harriet L. *Our Native Trees*. 425 pages, illustrated. Charles Scribner's Sons, New York.
- Lambeth, W. A. *Trees and How to Know Them*. 47 pages. B. F. Johnson Publishing Company, Richmond, Virginia. Contains keys for identifying the principal forest trees of the South.
- Mathews, F. Schuyler. *Field Book of American Trees and Shrubs*. 450 pages, illustrated. G. P. Putnam's Sons, New York.
- Noyes, William. *Wood and Forests*. 309 pages, profusely illustrated. Manual Arts Press, Peoria, Illinois. Especially useful for the information it gives about woods.
- Rogers, Julia E. *The Tree Book*. Royal octavo, 571 pages of text and 176 pages of illustrations. Doubleday, Page & Co., Garden City, New York. A popular guide to the trees of North America and to their use and cultivation; describes many species and gives much information.
- Sargent, Charles Sprague. *Manual of the Trees of North America* (exclusive of Mexico). Octavo, 812 pages, 644 illustrations of leaves and fruits. Houghton Mifflin Company, Boston. Describes all the known native species.
- Schaffner, John H. *Field Manual of Trees*. 149 pages. R. G. Adams and Co., Columbus, Ohio. Contains keys for identifying trees both in summer and winter; suitable for the pocket.
- Stone, Gertrude L., and Fickett, M. Grace. *Trees in Prose and Poetry*. 184 pages, illustrated. Ginn & Co., Boston. Discriminatingly chosen selections from legendary, historical, and fanciful literature, inspired by the common trees of the United States.
- Weed, Clarence M. *Our Trees: How to Know Them*. Guide and descriptions by the author, photographs from nature by Arthur I. Emerson. J. B. Lippincott Company, Philadelphia.

PART TWO — STARS

Why did not some one teach me the constellations and make me at home in the starry heavens which are always overhead? — CARLYLE

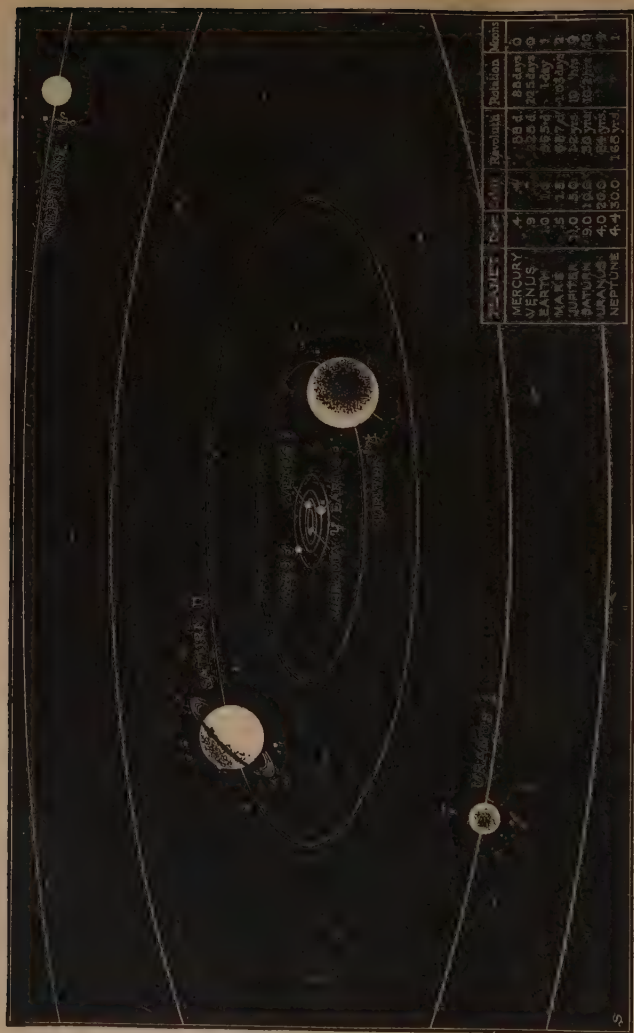


FIG. 108. The planets and their orbits. The planets are about 1000 times larger than they would be if they were drawn to the same scale as the orbits.

CHAPTER ONE

KNOWLEDGE OF THE STARS

CAN you remember looking up into the sky when you were a little child and wondering about the stars? And did you learn to recite the familiar lines:

Twinkle, twinkle, little star,
How I wonder what you are!
Up above the world so high,
Like a diamond in the sky.

Are you now too old to wonder about the stars or to wander in imagination among the celestial spheres? Should you like to know where shooting stars come from, what they are, and what becomes of them? Are the other stars like them? Do people live on the stars? If they do, can they see the earth, and what would the earth look like from the stars?

The science of astronomy. The science which treats of the heavenly bodies is called *astronomy*. It is interesting to study because it satisfies the spirit of wonder within us, our desire to know, which is the foundation of all science. It is also a most useful science. It enables us to determine directions and to keep accurate time. For thousands of years men have guided their course across the seas and over desert wastes by the stars, and by the use of astronomy explorers have found their way over unknown regions of the earth. Maps and surveys are based on observations on the stars. The surveyor who marks out the line of a railroad or the boundaries of a farm is using knowledge gained from study of the heavenly bodies.



FIG. 109. Yerkes Astronomical Observatory, Lake Geneva, Wisconsin.

Time measured by the movements of the heavenly bodies. If your clock gained 5 minutes a day, would it matter, provided that every other clock and watch did the same? People could keep appointments because their timepieces would agree. School would begin each morning when the clock pointed to nine o'clock. But after a few weeks a clock gaining 5 minutes a day would point to nine o'clock before sunrise. A little reflection will show that the length of a day is not determined by our clocks and watches, but that our timepieces must be made to conform to the actual length that the day has. Likewise the length of a year does not depend on any human law or decree. We might agree to call 360 days a year. If we did, after a while Christmas would come in summer and the Fourth of

July in winter. Like the day, the year has its own length. What determines the length of a day and of a year?

Fitting the calendar to the year. In the early history of the world much confusion arose because of the lack of a calendar, but before the beginning of the Christian era, Julius Cæsar, by the advice of the astronomer Sosigenes, decreed that the calendar year should be $365\frac{1}{4}$ days, every fourth year containing 366 days and the others 365 days. The actual length of a year is almost $365\frac{1}{4}$ days, but in 16 centuries the difference between the true length and $365\frac{1}{4}$ days caused the seasons to shift in reference to the calendar 10 days. To remedy this, Pope Gregory in 1582 decreed that the day following October 4 should that year be called October 15, thus making up the 10 days. He further decreed that the last year of each century should not be a leap year unless divisible by 400. Thus 1700, 1800, and 1900 were not leap years, although they are divisible by 4, but the year 2000 will be a leap year. This arrangement so nearly approximates the length of the real year that in 4000 years the seasons will shift not more than 1 day.

Astronomy the oldest of the sciences. When the ancient Assyrians and Egyptians went on a journey, they often traveled at night, for the day was hot. They did not ride on a railroad train or along a highway with a fence on either side, but guided their courses by the stars. They had no electric or gas lights or such lamps as ours, and so the light of the moon was more important to them than it is to us. Whether on a journey or at home,

they often spent much of the night with no roof over them but the great vault of heaven, and clouds or mist rarely obscured the stars. These ancient peoples, therefore, had many opportunities for observing the heavenly bodies, and although they possessed no telescopes they learned more about astronomy than most persons nowadays know. They knew what bright stars and what groups of stars could be seen in the east at a certain season. They could compute when the moon would rise, when there would be a new moon, and when an eclipse. They knew the polestar and that it is always in the north, and from their knowledge of astronomy they knew the directions and how to guide themselves across uncharted wastes.

How to know the heavenly bodies. Some fields of study are too wide to be passed over in a short time. They are rich enough for us to visit again and again. Only in this way can we see and appreciate the treasures that are there stored. We cannot become well acquainted with more than a few kinds of trees or birds in a single month. We may come to know them better as long as we have health to enjoy life. The same is true of the stars. The student might read the chapters in this book on the stars in an hour or two. It would be more profitable for him to read them a little at a time. The stars cannot all be seen to advantage at any one season. To study them most conveniently one should look at them night after night through the different months of the year.

It would be well to begin the study of the stars and constellations sometime in the fall, when a clear sky

permits them to be well seen, and to take them up again every week or two for several months and perhaps again the next year. In this way, little by little you will acquire an acquaintance with some of the brightest stars and most conspicuous constellations, and this will continue to be a source of pleasure to you in after years.

Reasoning as well as observation required in astronomy. By looking through a telescope you could see many stars too faint to be seen with the naked eye, but even the brightest stars would appear as points of light, just as they do when seen without a telescope. How, then, do we know that some of them are very large? Science has revealed to us many wonderful things in the heavens which the ancients did not know. Telescopes and other instruments are very useful to the astronomers, but what is seen by means of them would not afford much knowledge about the heavenly bodies if the astronomers did not reason correctly from the facts that they gather. The scientific method requires not only careful observations but also careful reasoning.

The questions that are asked in the chapters that treat of the heavenly bodies are intended to guide you in your thinking. Many of them may seem difficult to young pupils. Older students, even, will be puzzled to find correct answers to some of them. It would be well to give some attention to them early in your study, so that, as opportunity occurs for observing the heavens, some of them at least may be answered without the aid of teachers or of books.

CHAPTER TWO

THE UNIVERSE AND SOLAR SYSTEM

LYING with your back upon the earth and looking up into the blue sky, did you ever wonder what there might be far away in space? Is there a wall that bounds it all? If there is, what is beyond that wall? If not, how far does space extend? Are there other suns, larger, hotter, and more brilliant than our own? Are there great heavenly bodies, thousands of times as large as the earth, which no one on the earth has ever seen? Far out in space are there other worlds like ours on which beings like ourselves could live?

The earth, with everything on it, and all the heavenly bodies, seen and unseen, make up the *universe*. In every direction it stretches away through limitless space, a vast collection of giant bodies that the imagination can hardly picture. When we stand forth under the sky at night and think of

Clusters and beds of worlds and beelike swarms
Of stars and starry streams,

sweeping on and on through space, we are awed by the majesty of the spectacle before our eyes.

The stars. What are the twinkling points of light which our eyes behold in whatever direction we look on a clear night? They are great blazing suns, set here and there at vast distances through space. We do not see that they are farther from us than the clouds, except when a drifting cloud hides them from our view. Yet the clouds are only a short distance from us, floating in the air above us, while the stars are out in space so far away that even were we able to fly with the swiftness of

a nighthawk we could not reach them in a thousand years. The sun is a star, no larger or brighter than thousands of others; but it is much nearer to us, and that is why it gives us so much more heat and light and seems so much larger than the other stars.

The solar system. The earth and seven other worlds or planets, some smaller than the earth, others larger, revolve around the sun (Fig. 108). These are the *major* planets. The sun controls the motion of several hundred *minor* planets, which are of much smaller size also, as well as the movements of various comets and a host of meteors. Some of the major planets are attended by satellites that revolve around them as they themselves revolve around the sun. The moon is the earth's satellite, and some other planets have several moons or satellites.

The sun and all the bodies that revolve around it — the planets with their satellites, the minor planets, and the comets and meteors — constitute the *solar system*; that is, the system of the sun. Whether, like the sun, the other stars have smaller bodies revolving about them we cannot tell. They are so far away that at such distances bodies like our earth would be invisible to us. Yet it would seem reasonable to believe that each star is the controlling center of a great system of worlds like our own.

The vastness of the universe. The earth on which we live is so large that none of us will ever see more than a small part of its surface, and the vast mass of matter that lies deep in the earth's interior has never been seen by human eye. Yet the earth is but a small member

of our solar system, and our entire solar system is so small a part of the whole universe that blotting it out of existence would be only like wiping a speck of star dust from the sky. Well has the poet Emerson said: "If the stars should appear one night in a thousand years, how would men believe and adore; and preserve for many generations the remembrance of the city of God which had been shown."

The work of astronomers. In the vast voids of space between the heavenly bodies there is no air, and across them no sounds can pass. In them all is darkness and silence, and there the cold is of an intensity not known on earth. Nothing comes to us across this space except waves of light and heat and the mysterious force of gravitation, which all material bodies exert on each other. Yet from the information gained from these sources, astronomers have measured the distances to some of the stars, learned that certain of them are young and others old, and calculated the weights of the sun, moon, and many other heavenly bodies. By countless observations and by careful thought and long computations they have learned the secrets of the universe and have built them into a system so wonderful and so complete that of it the philosopher Laplace has said: "Contemplated as one grand whole, astronomy is the most beautiful monument of the human mind, the noblest record of its intelligence."

CHAPTER THREE

DETERMINING THE DISTANCES TO THE HEAVENLY BODIES

These mathematic men have thoughts that march
From sphere to sphere and measure out the blue
Of infinite space like roods of garden ground.

BLACKIE

A BABY reaches for the moon and a dog barks at it. Apparently they think it is near them. Can you tell merely by looking at it whether it is near or far away? Have you ever mistaken a town clock at night or some other artificial light for the moon and are you sure that the moon is farther away than objects on the earth? Doubtless you have read about the great distances of the sun, moon, and other heavenly bodies from the earth, and perhaps you have wondered how it is possible to learn the distance to an object that no one has ever been able to reach. Astronomers and surveyors do this in a rather simple way.

Determining distances without measuring them. A surveyor can find the distance to a tree on the other side of a river without crossing the river. On his own side of the river he drives two stakes and then carefully measures the distance between them. Then with his instruments he sights at the tree from each stake, measuring the angles that lines from each stake to the tree make with a line connecting the two stakes. The two stakes and the tree form a triangle of which he knows the length of one side and the size of two angles. By his knowledge of trigonometry he is then able to calculate the length of the other sides of the triangle and thus find the distance from either of the stakes to the tree. By ex-



FIG. 110. Determining distances to objects without measuring them.

amining Figure 110 you will note that the farther away the tree is the larger are the angles at the two stakes.

Finding the distances to the heavenly bodies. Astronomers use the method of the surveyor in finding the distances to the heavenly bodies. Two observers can sight their instruments on the moon from different points on the earth's surface and find the angles which the lines to the moon make with a line connecting the two points on the surface of the earth. They know the distance apart of the observers on the surface of the earth, and they can then calculate the length of the lines which extend to the moon (Fig. 111).

In measuring the distance to fixed stars, which are very distant from us, astronomers take observations at different times of the year and use the distance of the earth from the sun as one side of the triangle. Figure 112 will help to make clear how this is done.

Distances to some heavenly bodies. Suppose that Romulus and Remus, the traditional founders of Rome,

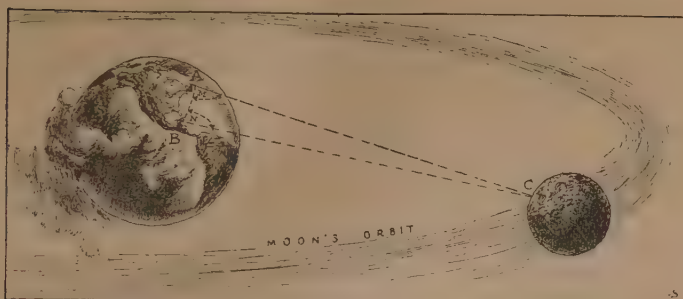


FIG. 111. How the distance to the moon is measured. If the astronomer knows the length of the line AB and the size of the angles M and N , he can compute the distance to the point C .

had started from Italy in 753 B.C. in an airplane that would carry them 125 miles an hour. In 2 days they might have reached North America, and on the third they would have crossed the continent and reached the Pacific Ocean. Keeping on around the world they would have arrived at their native land in about a week from the time they started. Suppose them to start again on a journey, this time to the moon, traveling at the same high rate of speed. The journey would have required about 80 days, and if they had started back to the earth at once it would have been more than 5 months before they reached their home again.

Suppose they had then set out for the sun. They would have taken 85 years to reach it and would have grown quite old before they arrived. If, not content with seeing so much of the universe, they had kept on through space, directing their swift flight toward the great planet Jupiter, the journey from the sun to

Jupiter would have required 441 years; for Jupiter is more than 5 times as far from the sun as we are.

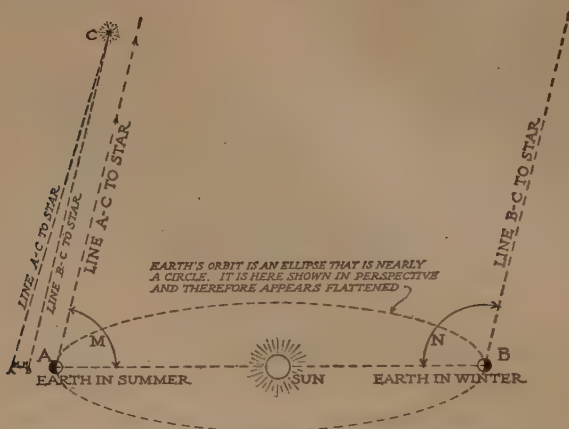


FIG. 112. How the distance to a star is measured.

If they had arrived at Jupiter in 227 B.C., and that same year had directed their course toward the orbit of Neptune, the most distant of all the worlds that revolve around the sun, they would not have reached the path of that planet until the year 1879.

Suppose Neptune in 1879 to have been on the opposite side of his orbit from the point where Romulus and Remus arrived, and that they had set out to meet him, traveling still at the rate of 125 miles an hour, or 3000 miles a day. Neptune is the slowest of all the planets; nevertheless, he moves along his path at a speed of about 200 miles a minute, which is farther than Romulus and Remus are flying in an hour. Although Neptune and our voyagers through space were moving toward

each other with such high speed, yet some 80 years would elapse before they would meet.

Within your lifetime let Romulus and Remus bid adieu to Neptune and set out for Alpha Centauri, the star that is nearest to our solar system. Their journeys made among the planets have occupied nearly 27 centuries. 7000 times 27 centuries would be required to reach Alpha Centauri, the nearest star. Many of the stars are hundreds of times as far away as Alpha Centauri. Only a few of them are within 400 trillion miles of the earth. Most of them are many times this distance from us, but it is believed that none are so far away as 1000 times this distance.

Some problems to be explained. Riding along a straight road in the country at night, did you ever notice a light in some house to your right or left, and, after riding for some minutes more, notice that it was still in nearly the same direction? Was the house near the road or far from it? Did you ever go along a city street and notice when you came to a cross street that the moon was right down that street? Going on another block, you saw the moon again right over another cross street, and so on, block after block. Was the moon following you? What other explanation can you give?

CHAPTER FOUR

THE STARRY HEAVENS

The snow-white clouds, whose fleecy wings unfold
The stars, that light your boundless breadth of blue,
Roll back your edges, tinged with deepest gold,
And softly let the peaceful wanderers through;
Till, one by one, they burst upon my eyes,
O'ertaking my young heart with sudden sweet surprise.

PRINCESS AMELIA

Go out and view the heavens at night. Like a great bowl or hemisphere dotted with twinkling points of light, the heavens appear above you. The other half of the sphere is invisible to you, but you can think of a great hollow sphere called the *celestial sphere*, within which is the little sphere we call the earth. Standing upon the earth, you are viewing the celestial sphere from the inside.

Look up at the sky and think what is meant by the celestial sphere. Is it at any definite distance from us, and is it like a wall with a certain thickness that shuts us in? Or do the words "celestial sphere" describe what we seem to see rather than what actually exists in space about us?

Horizon, zenith, and altitude. The line where the earth and sky seem to meet is the *horizon*. The elevation of a star above the horizon is its *altitude*. The point in the heavens directly overhead is the *zenith*. If a star is at the zenith, its altitude is 90 degrees, for there are 360 degrees in a circle and the zenith is one fourth of the way around the celestial sphere from the horizon to the starting point on the horizon. If a star is midway between the zenith and the horizon, its altitude is 45

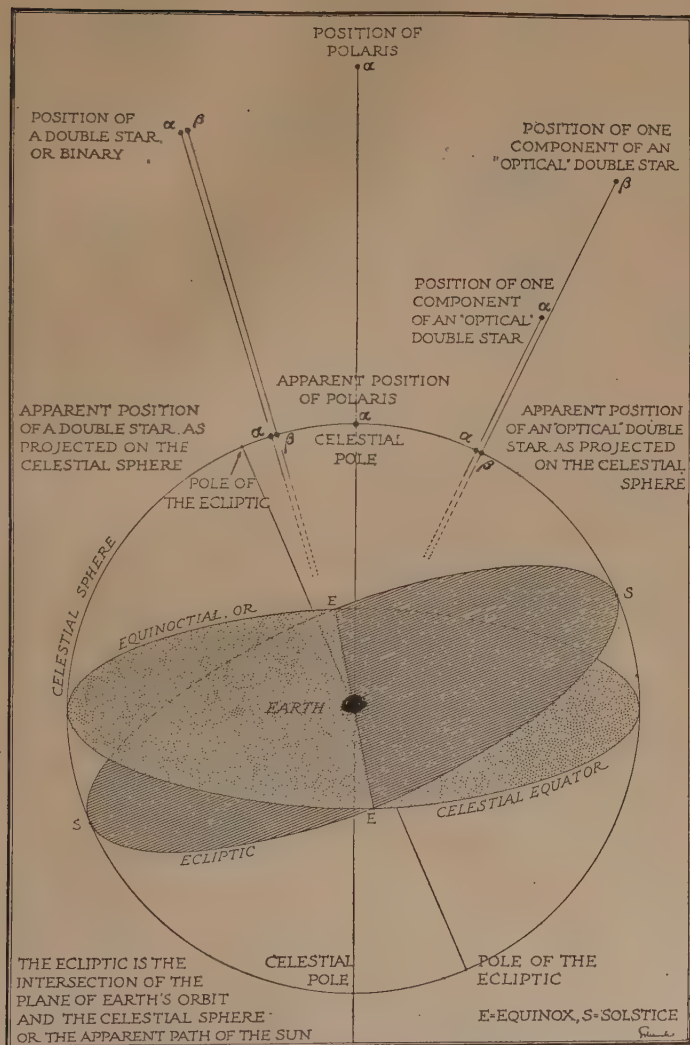


FIG. 113. See if you can understand everything that is on this drawing.

degrees. Likewise a star one third of the way from the horizon to the zenith has an altitude of 30 degrees; one that is two thirds of the way, 60 degrees; one that is four fifths of the way, 72 degrees.

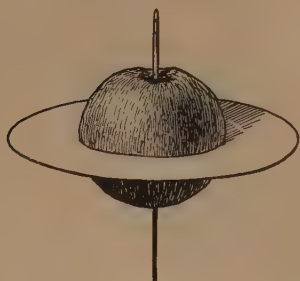


FIG. 114.

The celestial equator. A wheel rotates about a line passing through its center. The line about which it rotates is the *axis of rotation*.

The earth rotates about its axis, an imaginary line passing through the north and south poles. The plane passing through the center of the earth and perpendicular to the earth's axis is the *plane of the equator*. The line where this plane comes to the surface of the earth is the *terrestrial equator*, and the line where it comes to the celestial sphere is the *celestial equator*. Get a globe or use an apple or an orange to represent the earth. Then study out carefully what has been said in this paragraph. Cut an apple in halves and lay a circular sheet of paper between the halves, as shown in Figure 114. This may help you to understand the celestial equator. Be especially careful to understand what is meant by the word "plane."

The ecliptic. In the course of a year the earth revolves once about the sun. During this time the sun seems to move around the heavens in a circular path. This path is called the *ecliptic*. It is not the same as the celestial equator. The plane of the ecliptic is inclined to the plane of the equator $23\frac{1}{2}$ degrees, so that

the sun each year reaches that distance either side of the celestial equator. It is farthest north in June and farthest south in December. Since the sun is always on the ecliptic, astronomers find the position of the ecliptic in the heavens by observing the sun throughout the year.

The zodiac. The moon in its motion around the earth never gets very far from the ecliptic. The planets, too, keep near the ecliptic. Within a belt only 16 degrees wide—that is, 8 degrees on each side of the ecliptic—the moon and all the major planets may always be found. This fact was noticed by those who observed the heavens in ancient times, and they called the belt the *zodiac*, or zone of animals. They fancied they could see among the stars along this belt the outlines of various animals.

The constellations. The peoples of ancient times mapped out the heavens into divisions, which are called *constellations*. A few constellations have been added in modern times. The imaginary boundaries of a constellation extend far enough to meet those of surrounding constellations, so that the entire celestial sphere is covered with constellations and every star is assigned to some constellation or other. Many constellations include a prominent group of stars which the ancients supposed to form some object or the figure of an animal or man, and which gave to the constellation as a whole its name.

If you were to map out the celestial sphere into a number of areas, each of which included one group of stars, your map would probably be as good as those which we use. The names you would apply to the figures



FIG. 115. The constellation of Orion
(see page 204).

you could make out among the stars would probably be just as reasonable as the names which were applied by the ancients. But the names which were long ago given to groups of stars have become fixed by use, although in many cases it is not easy to see the forms of birds, reptiles, quadrupeds, mythological heroes or heroines, and various objects which the peoples of antiquity

imagined were among the stars.

Names of stars. Most of the bright stars, as well as the constellations, were given names before the beginning of the Christian era, and these names are still used. The brightest star in each constellation is called also by another name, Alpha, the first letter of the Greek alphabet. The next in brightness is Beta, the second letter; the next Gamma, the third letter; and so on through the Greek alphabet of twenty-four letters. After that the Roman alphabet is used. Astronomers also make use of star catalogs, which give the exact locations of hundreds of thousands of stars. They refer to a star by the name of the catalog containing it and its number in that catalog.

Magnitude of stars. The word "magnitude" does not refer to the actual size of a star, but to its brightness to our eyes. This brightness depends on the distance of the star from us and on how hot it is, as well as on its size. The brightest stars are said to be of the first magnitude; those barely perceptible, of the sixth magnitude; others coming between these classes are referred to as of the second, third, fourth, or fifth magnitude, according to their brightness. One hundred sixth-magnitude stars together would give as much light as one star of average first magnitude. With large telescopes stars of the seventeenth magnitude may be seen. Ten thousand such stars together would not give light enough to be visible to the unaided eye.

The number of stars of the smaller magnitudes is much greater than the number of stars of large magnitude. Those of the first six magnitudes to be seen north of the celestial equator, or within 35 degrees to the south of it, have been divided as follows:

First magnitude, 15; second magnitude, 48; third magnitude, 152; fourth magnitude, 313; fifth magnitude, 854; sixth magnitude, 2010.

The first-magnitude stars differ in brightness, Sirius, the Dog Star, being more than 10 times as bright as Aldebaran, which is of standard first magnitude. In the following list the fifteen first-magnitude stars visible in the Middle states and farther north are arranged in the order of their brightness. Those preceding Aldebaran are brighter than standard first magnitude; those following Aldebaran are less bright than the standard of their class:

Sirius	(sĭr'ĭ-ŭs)
Vega	(vē'ga)
Capella	(ka-pĕl'a)
Arcturus	(ark-tŭ'rŭs)
Rigel	(rĭ'jel)
Procyon	(prō'sĭ-ŏn)
Altair	(ăl-tair')
Betelgeuse	(bĕt'ĕl-gŭz' — u as in bur)
Aldebaran	(ăl-dĕb'a-răn)
Pollux	(pŏl'ŭks)
Spica	(spĭ'ka)
Antares	(ăn-tă'rĕs)
Fomalhaut	(fo'măl-ŏ)
Deneb	(dĕn'ĕb)
Regulus	(rĕg'ŭ-lŭs)

Most of these fifteen stars will be mentioned again. Their names and locations in the heavens can be learned when we study the constellations in which they are placed. On a summer evening or early in the fall one can see only seven or eight stars of the first magnitude. Most of the bright stars in the sky are of the second magnitude. One estimate of the number of telescopic stars places the total at about 300 millions, and it is probable that there are in the universe not nearly so many stars as there are people on the earth.

Apparent motion of the stars. The rotation of the earth on its axis makes the stars appear to rise in the east and set in the west, or, if they are far enough north, to revolve in circles around the north pole of the heavens. They seem to have another motion also, because of the

earth's revolution about the sun. Each successive night they rise nearly 4 minutes earlier, or, in the course of a month, about 2 hours earlier.

The stars do not appear to change their positions with respect to other stars. Any triangle that you may notice tonight with a certain star at each of its three angles will have the same shape and size whenever you look at it. However, some stars are actually moving very swiftly through space — perhaps hundreds of miles every second. This motion is not visible to you because the stars are so far away that their movements will not change their apparent positions within your lifetime. Do you understand how this can be true? Suppose a near object and a very distant object were each moved a certain distance, say a foot or a rod. Which one would have its direction from you most changed?

Twinkling of the stars. If you look through the air that is rising above a hot stove, the things you see appear to quiver. The twinkling of the stars is due to the light from them having to pass through the air that is about the earth before it gets to our eyes. When there are strong currents rising in the air above the earth, as in the air heated by a stove, the stars seem more unsteady than at other times. Stars near the horizon twinkle more than do those near the zenith, because light from them must then come through more air before it reaches our eyes. The planets shine with a steady light because they are comparatively near us, and in a telescope a planet shows a disk of some size instead of a mere point like a star. It sends light to us



FIG. 116. A photograph through a telescope of a portion of the Milky Way.

from many points instead of one, and except sometimes when near the horizon shines with a steady gleam.

The Milky Way. On any clear and moonless night you can see the Milky Way or Galaxy, a gauzy band of light stretching across the heavens. If the earth were not in the way you would see that it extends in a complete circle around the sky. It is several times the breadth of the moon, but irregular and of uneven brightness. For a distance it is divided into two bands. The

Chinese call it the Celestial River; the North American Indians, the Road of Souls. It is composed of millions of stars. Very few of the stars in the Milky Way are bright enough to be seen by the unaided eye, but together they send to your eyes enough light to make an impression, provided you are not receiving much light from the moon or other sources. These stars are much farther away than any of the bright stars.

HOW TO USE THE STAR MAPS

✓ It will be an easy matter to find on the maps the stars and constellations mentioned in the text. To locate them in the heavens is much more important and interesting. To do this, turn to the map that shows the appearance of the heavens at the season when you are making the observations. If the date or hour differs a little from those given at the bottom of the map, the position of the stars also will differ a little. Holding the map high in front of you, notice that the word "Zenith" indicates the place in the heavens that is directly over your head. Near this you will see, if the sky is clear, the constellations shown near the word "Zenith" on the map. Down near the horizon you will see those shown near the bottom of the map. Those toward the right side of the map will appear in the heavens somewhat to your right and those toward the left of the map in the corresponding position in the heavens. In using a map under which is printed "Looking South," remember that east is toward your left hand and west toward your right hand. The lines connecting stars on the map have no counterparts in the heavens, but they will make it easier for you to find the stars. If the map is held directly over the head, the stars on it will appear as they do in the heavens.

From hour to hour and from night to night the stars change their positions with reference to things on the earth, because of the motion of the earth itself. You should become accustomed to locating the constellations not with reference to anything on the earth, but with reference to other constellations, and to recognizing them by the arrangements of stars in them. However, in pointing out a star to another person, it is well to stand in such a position that the star appears to be directly over a telephone pole or some other near object which is unmistakable. If the other person gets in line with you and the pole, he can tell what star you mean, if you make clear to him how high he should look.

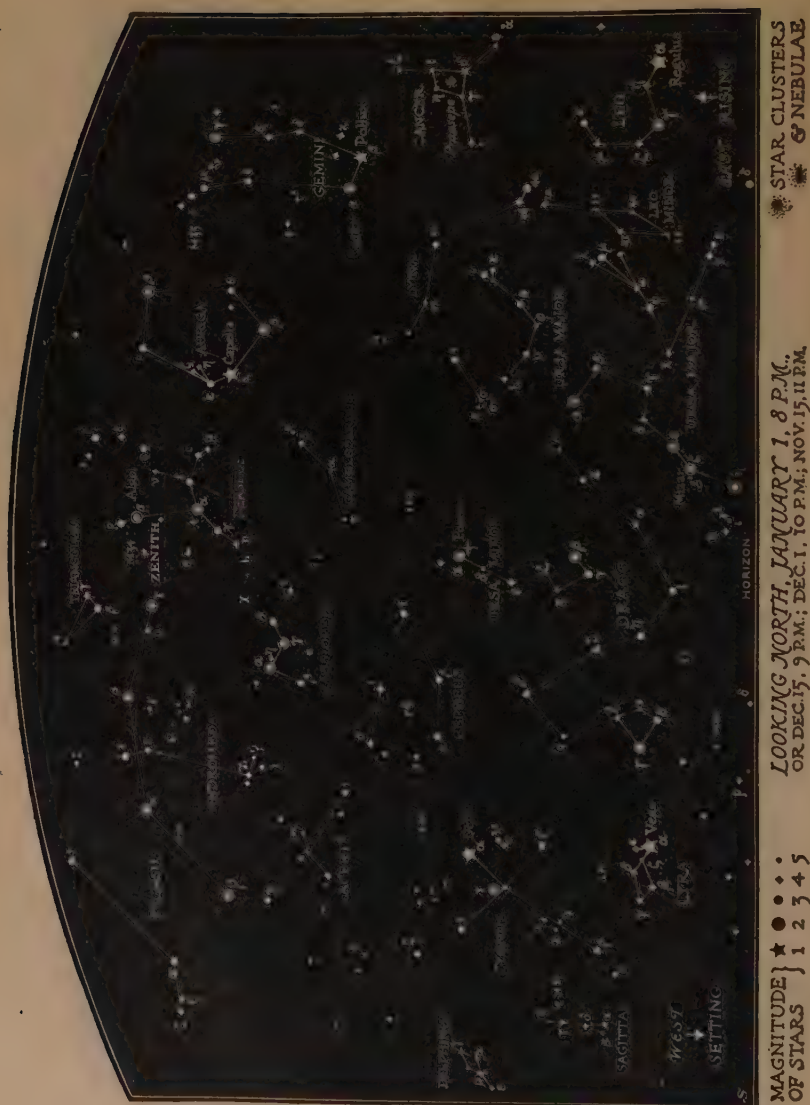
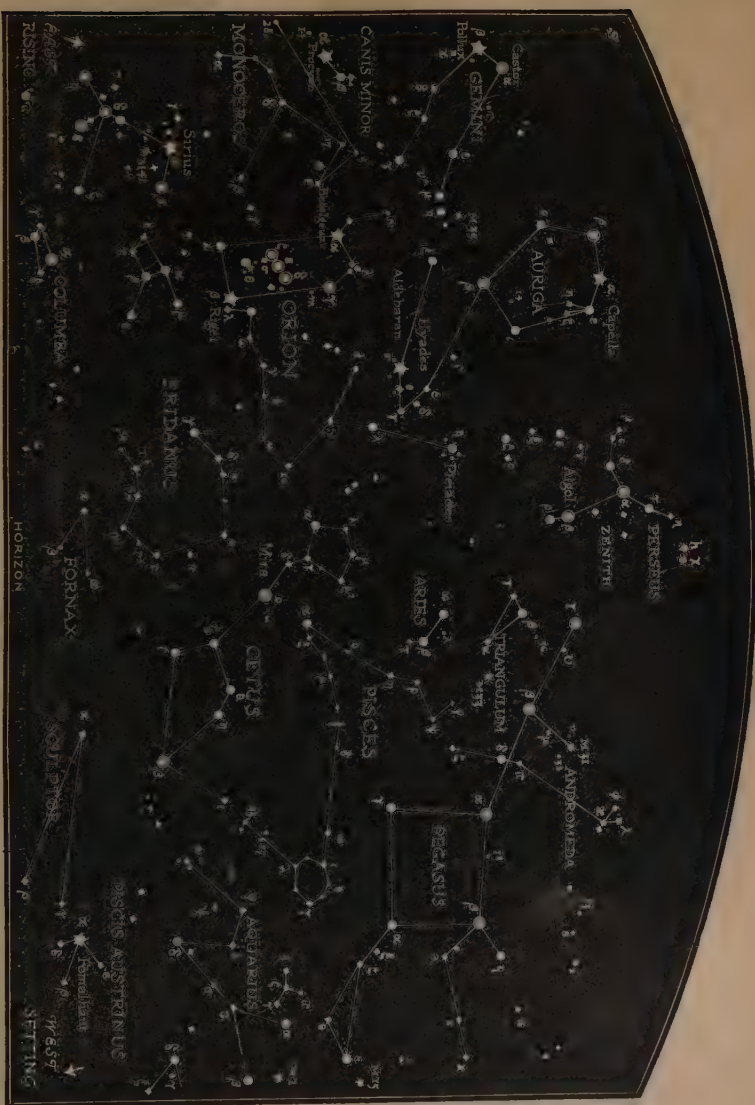


FIG. 117.

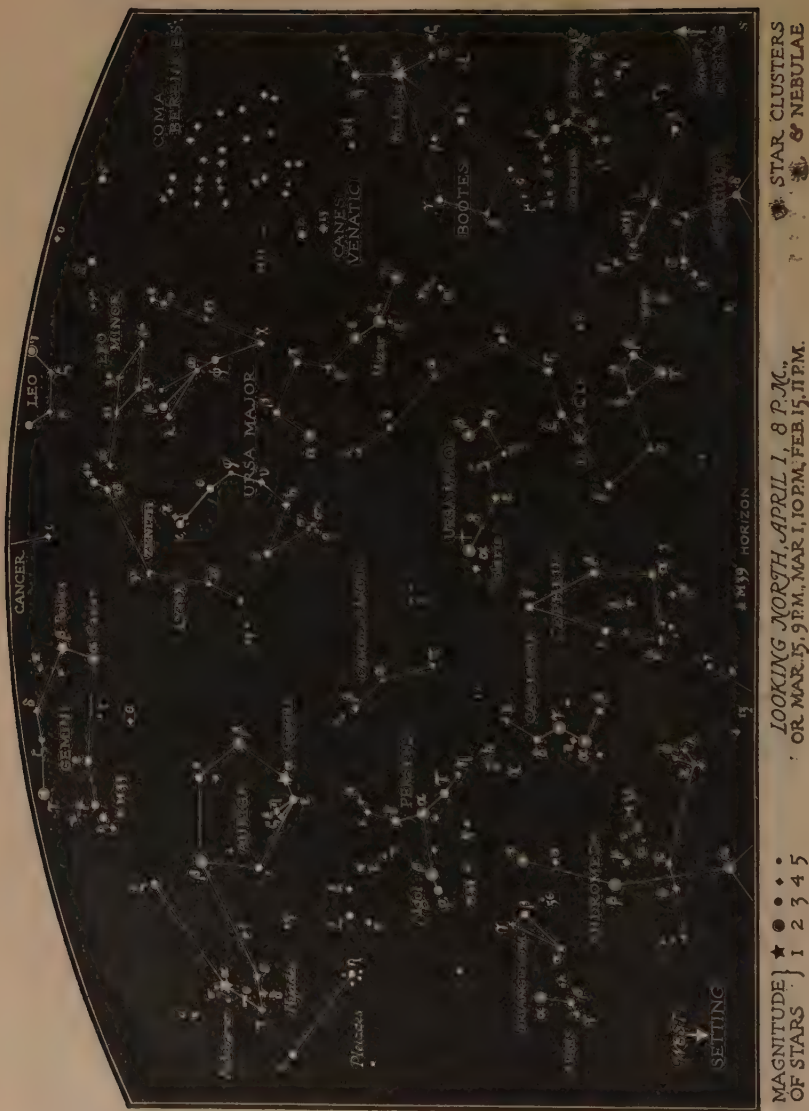


MAGNITUDE } ★ ● ● ● ●
OF STARS } 1 2 3 4 5

LOOKING SOUTH, JANUARY 1, 8 P.M.
OR DEC. 15, 9 P.M., DEC. 1, 10 P.M., NOV. 15, 11 P.M.

FIG. 118.

★ STAR CLUSTERS
● NEBULAE



MAGNITUDE } ★ ● ◆ ♦
OF STARS } 1 2 3 4 5

LOOKING SOUTH, APRIL 1, 8 P.M.
OR, MARCH 15, 9 P.M.; MAR. 1, 10 P.M., etc.

★ STAR CLUSTERS
◆ NEBULAE

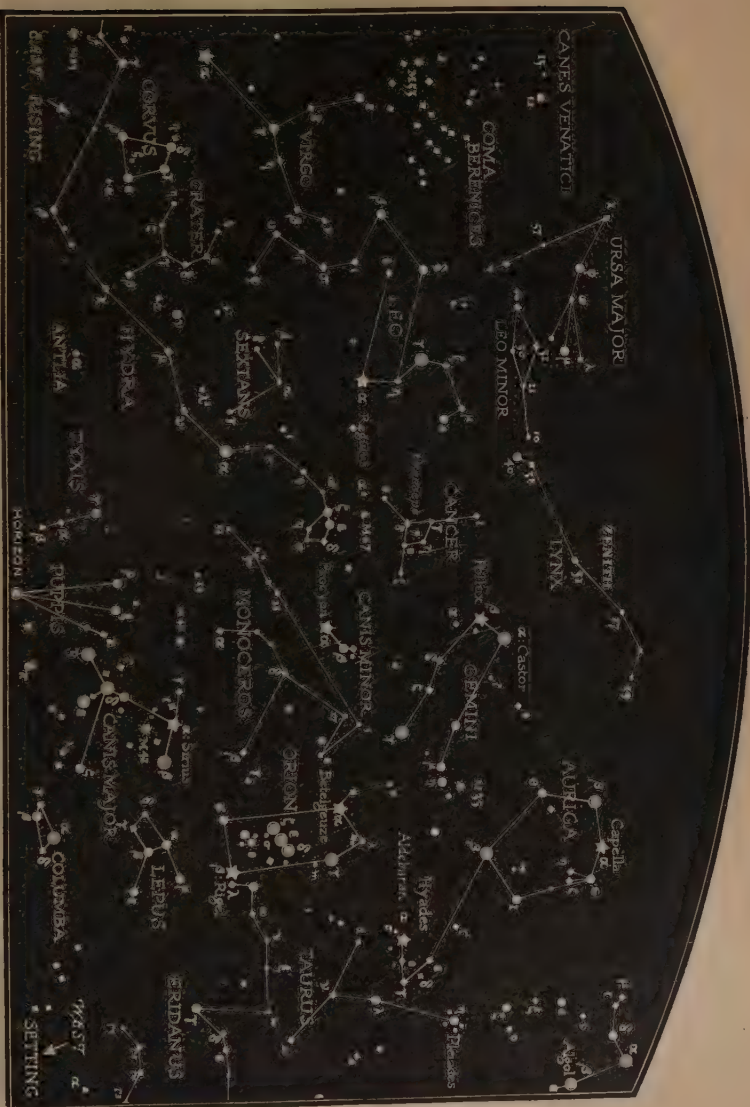
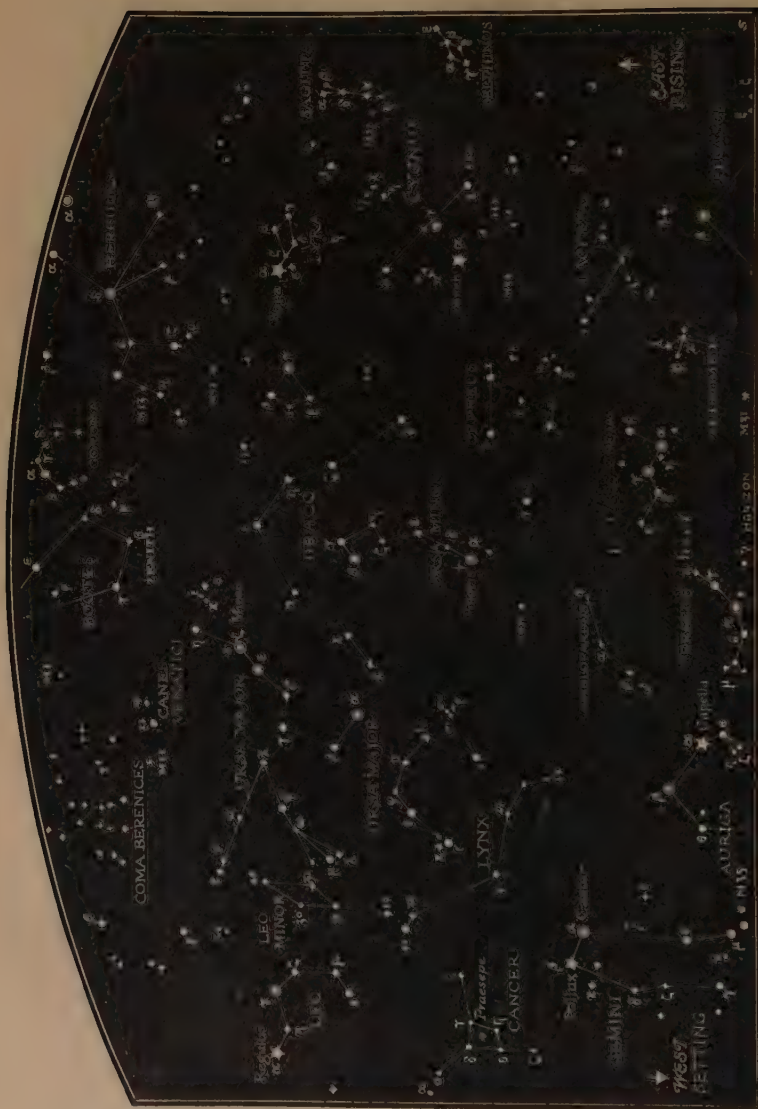


FIG. 120.

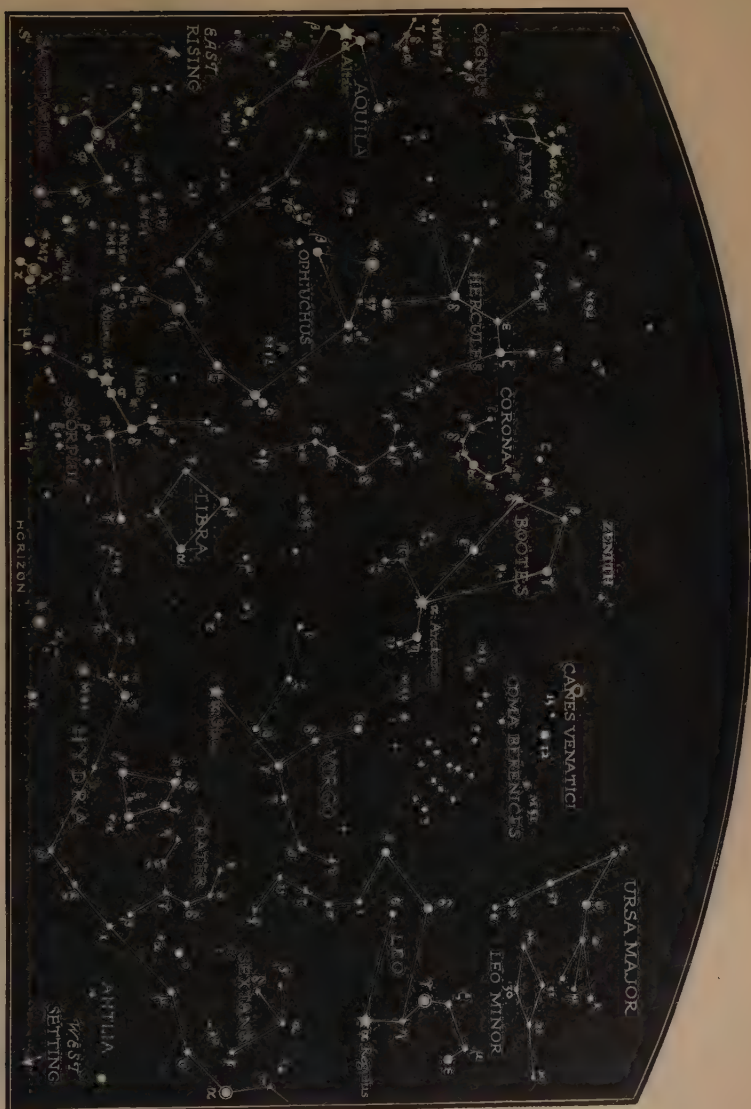


STAR CLUSTERS
& NEBULAE

LOOKING NORTH, JULY 1-8 P.M.
OR JUN. 15, 9 P.M., JUN. 1, 10 P.M.; MAY 15, 11 P.M.

Fig. 121.

MAGNITUDE } 1 2 3 4 5
OF STARS

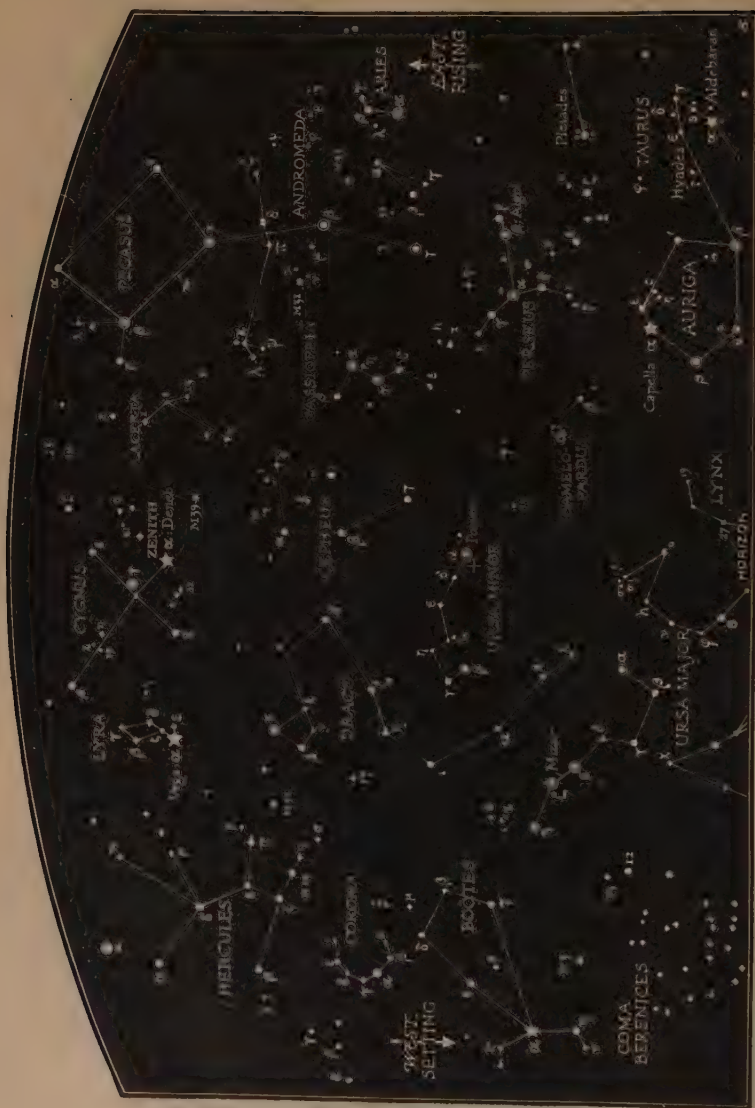


MAGNITUDE } ★ ● ● ● ●
OF STARS } 1 2 3 4 5

LOOKING SOUTH, JULY 1, 8 P.M.
OR JUN. 15, 9 P.M.; JUN. 1, 10 P.M.; MAY 15, 11 P.M.

FIG. 122.

★ STAR CLUSTERS
☉ NEBULAE



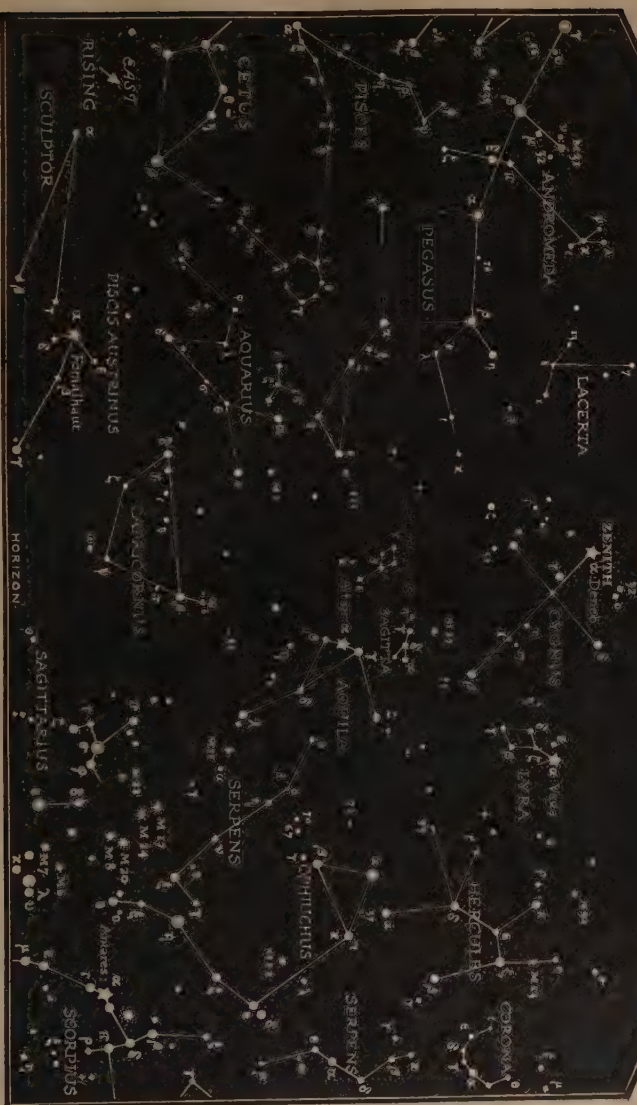
MAGNITUDE } ★ ● ● ● ●
 OF STARS } 1 2 3 4 5
 LOOKING NORTH, OCTOBER 1, 8 P.M.,
 OR SEPT. 15, 9 P.M.; SEPT. 1, 10 P.M.; AUG. 15, 11 P.M.

FIG. 123.

MAGNITUDE
OF STARS } ★ ● ● ● ●
1 2 3 4 5

LOOKING SOUTH, OCTOBER 1, 8 P.M.
OR SEP. 15, 9 P.M.; SEP. 1, 10 P.M.; AUG. 15, 11 P.M.

★ STAR CLUSTERS
☼ NEBULAE



CHAPTER FIVE

STARS NEAR THE NORTH POLE OF THE HEAVENS

I'm constant as the Northern Star,
Of whose true-fixed and vesting quality
There is no fellow in the firmament.

SHAKESPEARE

THE stars in some parts of the heavens are visible only at certain seasons of the year and certain hours of the night, but the constellations treated in this chapter remain above the horizon at all times. On account of the rotation of the earth they change their altitudes and directions, and they appear in different positions at different times of the year; but the stars near the north pole of the heavens will be visible on any clear night. Therefore he who becomes acquainted with them, as long as he remains in the northern hemisphere will see familiar faces wherever he goes. The people about him may all seem strange, or he may be quite alone, either in the wilderness or in a great city; yet he need not feel lonely, for his old-time friends among the stars will greet him night by night.

The Great Dipper and the Great Bear. You have often seen the Great Dipper. It is always visible on a clear night from any part of the northern hemisphere except near the equator. It forms a part of Ursa Major, the Great Bear; but the Bear is not so easy to find as the Dipper is, and a person has to use his imagination to see it. The handle of the Dipper forms the tail of the Bear — a very long tail which, according to mythology, Jupiter stretched in lifting the huge beast up into the heavens. The four stars forming the bowl of the Dipper are in the hind quarters of the Bear. The two

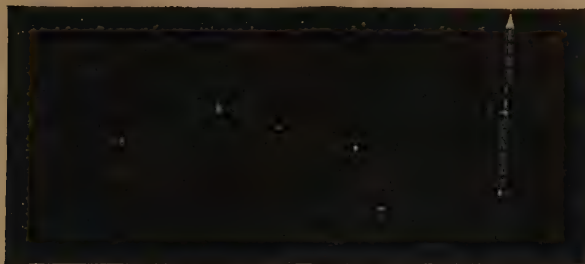


FIG. 125. The Great Dipper. The two stars farthest from the end of the handle point to the North Star.

of these farthest from the handle are called the Pointers, because they point to the North Star. The Bear's nose is as far in front of the Pointers as the bend in his tail is behind them.

Finding the North Star. A line through the Pointers of the Great Dipper and directed away from the bottom of the bowl passes very near the North Star, which is also called Polaris, or polestar. It is of about the same brightness as the stars in the Dipper. Some persons are surprised when the North Star is first pointed out to them, to find that it is so high above the horizon. Its altitude depends on the latitude of the observer. If you are in Maine or Minnesota, about 45 degrees north of the equator, the North Star appears halfway up from the horizon to the zenith. If you are in the latitude of Tennessee, then the altitude of the North Star is only about 36 degrees. Knowing the latitude of your home and the directions, you could find the North Star by looking north and up from the horizon the same number of degrees as your latitude. When away from home you can, by the aid of the Pointers, find the North Star

and in this way tell the directions on a clear night. Distances in degrees may be estimated by remembering that from the horizon to the zenith is 90 degrees. Shorter distances may be estimated by comparing them with parts of the Great Dipper. The Pointers are 5 degrees apart, and from the nearer one to the North Star is a little less than 30 degrees. The open part of the Dipper bowl is 10 degrees across; the handle is 16 degrees long. Study these distances until you are able to estimate accurately a given number of degrees on the celestial sphere.

Light from the North Star. Although brighter than any star near it, the North Star is much surpassed by stars in other parts of the heavens. It is a second-magnitude star and not nearly so bright as stars of the first magnitude. In recent years telescopes have been constructed that photograph stars as faint as the twentieth magnitude. About fifteen millions of such stars would be required to give as much light as the North Star. Most stars are more distant than the North Star, but some stars are nearer. Light traveling at the rate of 186,330 miles a second requires 44 years to come from the North Star; so, if it had been eclipsed 40 years ago by some dark body near it, 4 more years would pass before we would know of the eclipse.

The Little Dipper. When asked to point out the Little Dipper, people are likely to find such figures in different parts of the heavens. The only figure properly called the Little Dipper is in the north, in the constellation of Ursa Minor or the Lesser Bear. The North

Star is at the end of the handle. A bent line of faint stars may be traced from it to the bowl, formed by four stars. The two farthest stars are about as bright as the polestar; the others are fainter. The farthest one is about 18 degrees from the North Star and not quite in the direction of the star at the end of the handle of the Great Dipper.



FIG. 126. Cassiopeia. The brighter stars in this constellation form a flat W.

The north pole of the heavens. Whether either Dipper will hold water depends on the time at which you look at it, for both revolve around the north pole of the heavens. This is not quite the same as saying that they revolve around the North Star, which is about $1\frac{1}{8}$ degrees from the north pole, the point to which the axis of the earth is directed. Of course their apparent revolution is due to the rotation of the earth on its axis. With 10-inch telescopes some 150 stars nearer to the pole than Polaris may be seen.

Cassiopeia. On the other side of the North Star, and at about the same distance from it as the Great Dipper, is Cassiopeia. This constellation contains several second- and third-magnitude stars arranged so as to form a rather flat W. It is also called Cassiopeia's Chair, for in certain positions the constellation looks something like a chair. In mythology Cassiopeia was



FIG. 127. Can you explain why it is that the Dipper and other constellations in the northern sky seem to revolve about the polestar?

a queen, the wife of Cepheus and mother of Andromeda, who was rescued from a sea monster by Perseus. There are constellations named after all of these characters.

Draco, the Dragon.

The Dragon may be traced, as a winding line of stars, about halfway around the pole. The tail is between the two Dippers. The head is about as far from Polaris as Cassiopeia or the bowl of the Great Dipper, and about equally distant from these.

Some questions for thought. At what place on the earth would the North Star appear directly overhead? Where would it appear to an observer located 10 degrees north of the equator? In what direction could you travel without changing the altitude of the North Star? Can you travel without changing your horizon?



FIG. 128. Draco, the Dragon.

CHAPTER SIX

OTHER PARTS OF THE NORTHERN SKY

THE constellations described in the last chapter are so near the north pole of the heavens that they are always wholly or partly above the horizon of observers in Canada and the greater part of the United States. The constellations mentioned in the present chapter are also in the northern sky, but not so near the north pole. These may pass below the horizon for a time each day. Their location may be found with the aid of the maps. When looking at the constellations, think of north as the direction of Polaris, the polestar, and south as away from it. The constellations appear to move westward 15 degrees an hour, owing to the eastward rotation of the earth. They remain all the time at the same distance from the north pole of the heavens.

The Northern Cross. This figure lies in the constellation Cygnus, which is nearly overhead in the early evening in September and October. Later in the fall it is farther west and in the summer farther east. The brightest star, Deneb, is at the head of the Cross. It is a little brighter than Polaris and 45 degrees from it. The foot of the Cross is toward the southwest, more than 20 degrees from the head. An almost straight line of stars connects them. The foot and the ends of the arms are each marked by a star of the third magnitude. Where the arms join the main piece is a second-magnitude star. The cross looks like the frame of a huge kite. The ancients imagined they could see a swan, Cygnus, with wings spread out in the direction

of the arms of the Cross. The bright star, Deneb, is in the tail of the swan, and its neck is stretched forward as if it were headed for a warmer climate.

Lyra, the Lyre. This constellation is next to Cygnus and west of it. In it is one very bright star, called Alpha Lyræ, or Vega. This star is 52 degrees from Polaris. Throughout the summer it is one of the most attractive stars in the heavens.

It is visible also in fall

and winter, but is not likely to be seen in the evening in February or March. It is near the spot in the heavens toward which the sun, with the earth and all the other bodies of the solar system, are moving (page 210).

Pegasus. If you look about 40 degrees southeast of the Northern Cross, you will see a large square, known as the Great Square of Pegasus. The stars at the corners are of the second magnitude, and the sides are about 15 degrees long. Pegasus was a winged horse. The stars of the square lie in the body of the horse, but no hind quarters are to be seen. The square may be seen in the evening throughout the latter half of the year.



FIG. 129. Cygnus, the Swan. The bright star, Deneb, is in the back part of the body. It will help the reader easily to locate this constellation if he holds the book over his head and looks at the picture from below, while he faces the north.

Andromeda. Andromeda is overhead at about nine o'clock in the middle of November. It contains three second-magnitude stars in a line extending east and north from the northeast corner of the Great Square of Pegasus. The star at the corner of the Square belongs to both constellations. ▲ line drawn from this star to Polaris and extended beyond it will strike the Great Dipper near where the handle joins the bowl.

Perseus. Perseus is high in the sky at the beginning of the year. It may be recognized by stars arranged in the form of a hook, or somewhat like the letter J. The brightest of them, Alpha, is 40 degrees from the North Star in a direction opposite to that of the bowl of the Little Dipper. This curved line of stars forms only a part of the constellation Perseus. Beta Persei, which is the next to the brightest star in the constellation, does not form part of the J but lies about 9 degrees south and a little west of Alpha.

✓ **A variable star.** Having found Beta Persei, which is also called Algol, you will be interested to know something about it, for it is a wonderful star. For 60 hours it continues to be of the second magnitude and to show no change in brightness. Then it grows dimmer, losing about five sixths of its light. In less than 5 hours after obscuration starts, it begins to brighten again, and in $3\frac{1}{2}$ hours more it is as bright as ever.

This change in brightness is explained by supposing a dark or faint companion to pass in front of it and partly eclipse it, the period of revolution being about 68 hours, 49 minutes. Although no companion can be seen, we feel sure that this explanation is correct, not merely

because it seems the most reasonable to account for the gradual obscuration and regular recovery of brightness, but also because of information about the motion of Algol afforded by that marvelous instrument, the spectroscope. An examination of the light by this instrument enables us to tell whether a star is approaching or receding, and how fast. By this means we know that 17 hours before Algol becomes faintest, it is receding at the rate of nearly 27 miles a second, and 34 hours later it is approaching us at the same rate. Algol and its dark companion are revolving around their common center of gravity. When the dark companion is coming toward us, Algol is receding, and vice versa. The period of revolution, less than 3 days, is very short. Astronomers believe that Algol is about 1,160,000 miles in diameter; its dark companion about 840,000 miles; and the distance between their centers only about 3,250,000 miles. Algol is only one of a number of variable stars.

A new star. The constellation Perseus is notable also because of a new star which appeared in it in February, 1901, and attracted much attention. In 3 days from the time it was first noticed it became one of the brightest stars in the heavens. It faded rapidly and by the end of the year could no longer be seen with the naked eye. It is still visible with the best telescopes. Like other temporary stars, it turned red as it faded. The records tell us of a few other new stars.

Auriga, the Charioteer. This constellation is on the opposite side of the pole from Lyra. Its brightest star, Capella, is of the same brightness as Vega and 7 degrees nearer the pole. When you have learned to recognize

Orion, you will see that Capella is midway between the belt of Orion and the North Star. It gives out 120 times as much light as the sun. In other words, 120 suns at the distance of Capella would give us no more light than we receive from Capella. As its color is like that of the sun, it is probably of about the same temperature, and in order to give out so much more light it must be many times as large as the sun. Capella is far enough north to be above the horizon most of the time, but in August and September, when Vega is almost overhead, Capella is very low and not visible from the Southern states until late in the evening. What effect would it have on us if this star were to come within 100 million miles of the earth?

Boötes. Following the curve of the Big Dipper handle, a line extended about 30 degrees farther will come to Arcturus, a bright star with a reddish tinge. It is in the constellation Boötes, the Herdsman, and is one of the four brightest stars we can ever see in this latitude, the others being Sirius, Vega, and Capella. Arcturus is mentioned in the book of Job, but not until recent years has much been known about it or about any of the stars. Arcturus is much brighter than the North Star, although it is probably little, if any, nearer to us. Some astronomers think it is more than twice as distant as the North Star. It is moving through space many miles a second and coming several miles nearer to us each second. Within your lifetime you will not detect any change in its place among the stars, but since its position was determined by the Egyptian astronomer, Ptolemy, in the

second century A.D., Arcturus has moved more than 1 degree.

In the winter months Arcturus will not be seen in the early evening, but by the first of March it rises about eight o'clock, coming into view a little earlier each succeeding night. During July and August it may be seen early in the evening high in the southwest.

The Northern Crown. This little constellation lies 20 degrees northeast of Arcturus. The Crown is open toward the north. The brightest star in it is of the second magnitude and is known as the Gem of the Crown. This is a pretty constellation on a clear night.

Problems for study. Which of the constellations you have been studying remain above your horizon all the time? How far in degrees from the north celestial pole may a star be without passing below the horizon as the earth rotates? Would you find it the same if you were farther east or west on the earth, or farther north or south? Do not become discouraged if you find some of the questions difficult. Performing the experiment indicated below will enable you to answer some of them.

If you have no globe so mounted that you can make it rotate, push a long needle or stiff wire through an apple or an orange. The equator will be an imaginary circle midway between the two points where the needle comes through. Mark on this globe a spot about as many degrees north of the equator as you are north of the earth's equator. Imagine a small ant to be on this spot. Direct the axis (needle) toward the North Star and, *keeping it so directed*, turn the globe or fruit

around. Will the ant be able to see the star during the whole rotation? Will any other stars remain visible during an entire rotation? Will any stars be visible during the greater part of the rotation but not through all of it?

The celestial equator is where the plane of the earth's equator, if extended, would meet the celestial sphere or sky (page 174). It is midway between the north and south poles of the heavens; that is, midway between the points where the earth's axis, if extended, would meet the celestial sphere. At the beginning of spring, March 21, and the beginning of autumn, September 23, the sun is on the celestial equator and the days and nights are equal. During the spring and summer the sun is north of the equator and the days are longer, for it remains above the horizon more than half the time. Stars still farther north remain above the horizon during the greater part of the twenty-four hours. Can you tell how far north they must be not to set at all? How far north would you have to be to see the sun at midnight? Do not think that the answers to the last two questions are the same.

CHAPTER SEVEN

OTHER STARS AND CONSTELLATIONS

The sad and solemn night
Hath yet her multitude of cheerful fires;
The glorious hosts of light
Walk the dark hemisphere till she retires;
All through her silent watches, gliding slow,
Her constellations come, and climb the heavens, and go.

BRYANT

THE constellations described in the previous chapters lie partly or wholly north of the parallel of 30 degrees north. Nearer to the equator there are some constellations that are brighter than any of these. Being farther south, they are below the horizon a larger part of the time. Each is visible in the evening for about half of the year. By looking for them at different seasons you can find all the stars and constellations mentioned in this chapter.

The Pleiades. To learn the constellations located at a distance from the pole, it may be easiest to start with the Pleiades, or Seven Sisters — a cluster of stars erroneously called by some persons the Little Dipper. It is known to many who have never given much attention to the heavens. An ordinary eye can see only six of the sisters. An exceptionally good eye can make out nine under good conditions, and even more at times. With opera glasses you can easily see several others, and with a 3-inch telescope about one hundred. Photographs of this cluster, taken with a photographic telescope, show some three thousand stars. The Pleiades are more distant than the brighter stars. Two of those you see are fourth-magnitude stars. Alcyone, the only

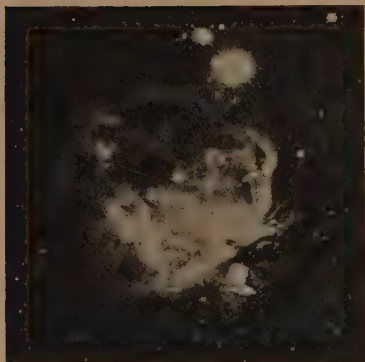


FIG. 130. The great nebula of Orion photographed through a telescope.

one as bright as the third magnitude, would appear many times as bright as Sirius, the brightest star in the heavens, if it were no farther away.

Southeast of the Pleiades you will see a V with a red first-magnitude star at the end of one side. This V, known as the Hyades, forms the face of Taurus, the Bull, and the bright star Aldebaran, one eye. The Pleiades form the shoulders of the Bull. The rest of his body is not represented in the constellation, but the tips of his long horns are marked by a second- and a third-magnitude star. He is charging upon Orion, the Hunter.

Orion, the Hunter. Orion, the most brilliant of all the constellations, is well known, and often attracts attention on a winter evening. In November it may be seen in the east before nine o'clock, and by Christmas, at six o'clock. By the middle of May it sets too early to be seen, but through the summer it may be seen before sunrise. The bright stars Betelgeuse and Bellatrix mark the shoulders of the Hunter, and Rigel, which is still brighter, one foot. Three second-magnitude stars in a straight line about 3 degrees long form the belt, from which hangs the sword composed of three stars not so bright as those in the belt. Theta, the star

at the middle of the sword, is hazy. A telescope shows that it consists of six stars and a great quantity of star mist, forming a nebula. With a telescope many nebulae can be seen in the heavens, but with the naked eye very few. The sun, with the earth and other bodies that revolve around it, is believed to have been a nebula hundreds of millions of years ago.



FIG. 131. Canis Major, or the Big Dog. Sirius, the brightest star in the heavens, is in this constellation.

Sirius, the Dog Star. Orion, the Hunter, is followed by the Big Dog, Canis Major, whose brightest star is Sirius. Canis Major is south of the ecliptic and rises a little later than Orion. Sirius is farther south than any other first-magnitude star visible in this latitude throughout the winter evenings. It is the brightest in the heavens, giving us 11 times as much light as an average first-magnitude star. If it were no farther away than the sun, it would give us more than 40 times as much light as the sun; but it is about 550,000 times as far away. Consequently the light we receive from it is

$$\frac{1}{(550,000)^2}, \quad \text{or} \quad \frac{1}{302,500,000,000},$$

of the amount we should receive if it were at the sun's distance.

Sirius is, nevertheless, one of the nearest stars. If the others were no farther away, many of them would appear much brighter than Sirius. Not all the faint stars, however, owe their dimness to their great distance, for they differ much in actual size and brilliancy. Around Sirius revolves, in a period of slightly more than 50 years, a star which can be seen only with a large telescope. For years at a time it is so near Sirius that even large telescopes do not enable astronomers to distinguish it. In 1916 it was at its farthest from Sirius. It will be visible with a large telescope for quite a number of years.

Like the moon, Sirius has been an object of superstition. In the latter part of summer it rises just before the sun, and the ancients associated the approach of the sun to the Dog Star with the season when malaria and some other diseases were prevalent. They supposed that in some way the Dog Star exerted an evil influence on health, and even yet we hear of the "dog days." How many other absurd notions have been held without any better reason than this!

The Little Dog. The Hunter has another dog, Canis Minor, whose bright star, Procyon, is east of the shoulders of Orion and so appears later above the horizon. It rises 15 or 20 minutes before Sirius, from which it is about 20 degrees northeast. It is nearly the same distance east of Betelgeuse, so that the three are at the corners of an approximately equilateral triangle. Not nearly so bright as Sirius, it is, nevertheless, one of the brightest stars in the heavens, and, like Sirius, one of the nearest to us. In 1896 Procyon was dis-

covered to have a companion that revolves around it in about 40 years.

The Twins. North of Canis Minor and northeast of Orion is the constellation Gemini, the Twins. Their heads are marked by two bright stars, Castor and Pollux, about $4\frac{1}{2}$ degrees apart, and their bodies by two parallel lines of stars extending toward Orion. A line drawn from Polaris to Procyon would pass between Castor and Pollux. This constellation is crossed by the ecliptic and is one of the twelve constellations of the zodiac. Castor and Pollux are interesting for several reasons. Some three centuries ago, when Greek letters were assigned to the stars in Gemini, Castor was called Alpha, and Pollux, Beta; but as Pollux, which is south and east of Castor, is now the brightest in the constellation, they are thought to have changed in brightness. Being farther north than the bright stars previously mentioned in this chapter, they remain longer above the horizon and may be seen in the evening from November till June. In spring they are west of the meridian, or plane which passes through the zenith from north to south. They were supposed by the ancients to have a favorable influence over navigation and were often represented in the figureheads of ships.

Double stars. Castor is what astronomers know as a *binary* or *double star*. So close to it that you cannot distinguish it is a star bright enough to be easily seen without a telescope, if it were not near any other star. The two are not only apparently near when seen with a telescope, but, as was discovered about 200 years ago, are really associated, although in all that time they

have not completed one revolution around their common center of gravity. By means of the spectroscope it has been discovered that each of these stars is double; so we know that Castor is really a system of four stars.

Many other instances of double stars are now known; that is, many stars which appear to the unaided eye as single points of light are shown by the telescope to consist of two stars. In some cases the two are not associated, but merely happen to be in the same direction from us, one of them much more distant than the other. These are called "optical doubles." The binary star consists of two that revolve around a common center of gravity. Even these are in many cases farther apart than are the earth and the sun; but their distance from the earth is so immense that they appear to us as one point. Hundreds of stars that appear single in the best telescopes are resolved into double stars by the spectroscope. Many thousands of stars are now known to be binary, and nearly one hundred have been found to consist of more than two stars each. Mizar, at the bend of the handle of the Big Dipper, is quadruple; that is, it consists of four stars; Polaris, the North Star, consists of four stars; and Theta Orionis, the star at the middle of the sword of Orion, consists of six stars enveloped in a nebula.

Aquila, the Eagle. Starting with that star in the bowl of the Little Dipper farthest from Polaris, a line drawn to Vega and extended as much farther will come to Altair, a first-magnitude star midway between two stars of the third magnitude. These three belong to the constellation Aquila, the Eagle. It is on the edge of the

Milky Way and near the celestial equator. It is visible in the early evening from June until December. With Vega and Deneb, Altair forms a bright triangle in the sky that can be seen prominently overhead during August and September evenings.

Leo, the Lion. In the latter part of winter, as soon as the sun has set, Leo, the Lion, is conspicuous in the eastern heavens. As the season advances, it will be found higher above the horizon, appearing nearly overhead or a little south of the zenith at nine o'clock in April and west of the meridian in June. Its brightest star, Regulus, which marks the heart of the Lion, lies about 12 degrees north of the celestial equator. Denebola, at the end of the tail, is a bright second-magnitude star between Regulus and Arcturus and somewhat nearer the former. The stars in the front part of the Lion make a good Sickle, with Regulus at the end of the handle. A line drawn through the Pointers of the Great Dipper from the North Star will pass a little west of the Sickle.

Leo is one of the twelve constellations which make the zone of animals, or zodiac, that lies along the ecliptic. Regulus is on the ecliptic, so that in August the sun passes exactly between it and the earth. It must be far larger than the sun, for it is all the time giving out a thousand times as much light. If it were not farther away than the sun, its light and heat would be unbearable, but it is so far away that its light is more than 70 years in reaching us. It is millions of times as distant as the sun, and its distance is increasing at the rate of nearly 150 millions of miles a year. If the sun were as far

away as Regulus, we could see it only with the aid of a telescope.

The constellations of the zodiac. The zodiac, or zone of animals, was divided by the ancients into twelve parts called *signs*, each of which was named after a constellation. The symbols or signs used for the twelve divisions of the zodiac may still be seen in almanacs, and various other places, as in the marble floor of the rotunda of the Library of Congress. In order they are:

♈ Aries, <i>The Ram</i>	♎ Libra, <i>The Balance</i>
♉ Taurus, <i>The Bull</i>	♏ Scorpio, <i>The Scorpion</i>
♊ Gemini, <i>The Twins</i>	♐ Sagittarius, <i>The Archer</i>
♋ Cancer, <i>The Crab</i>	♑ Capricornus, <i>The Goat's Horn</i>
♌ Leo, <i>The Lion</i>	♒ Aquarius, <i>The Water Carrier</i>
♍ Virgo, <i>The Virgin</i>	♓ Pisces, <i>The Fishes</i>

After a few of the zodiacal constellations have been learned, the others can be more easily located by their position with respect to those learned first. A study of the planets will help you to find them, for the planets are always in one or another of these constellations.

Families of stars. The star we call the sun, with its planets and satellites, is moving at the rate of about 12 miles a second away from a point in the heavens near Sirius. About one hundred other stars have been found to be moving in a similar manner. These stars may be thought of as a family whose members had a common origin. The Pleiades and many faint stars in the same region are moving in one direction and with one speed. They constitute another great family of suns. There are many such families in the universe.

CHAPTER EIGHT

SOME THINGS TO OBSERVE AND EXPLAIN¹

CAN you see stars at nine o'clock in the evening which could not be seen at eight o'clock? Are any stars visible at eight o'clock which disappear before nine? On a winter evening are the same stars visible as during a summer evening? Do the stars move? Do they change their positions with respect to one another? Does their brightness change in the course of an evening? Does it differ on different evenings? Do stars near the horizon twinkle less than those higher up? Do stars differ in color? Does a star ever change its color?

If you were to go a long way from home, would you see the same stars you saw at home? Would you see any different ones? If you were to count all the stars visible to your unaided eye, would the number be more or less than 600? more or less than 6000? Can you see more stars on some evenings than on others? Could you see the greatest number of stars from your own home, from a mountain top, or from a ship on the ocean?

These questions are to guide you in your observations and to give you something to think about. Merely reading them over is of no use, and you need not seek answers in books. When you can answer any of them because of observations you have made yourself, then see if you can account for what you have observed. To do this with half the questions, even if your answers are partly wrong, is better for you than to get the right

¹ In order to answer correctly the questions in this chapter, the stars must be observed at different times.

answers to all of them without understanding the reason. The explanations for many of the things you can observe about the stars may be found in some of the following facts. This knowledge is of little value unless you understand how these facts account for what you observe.

You see stars and other objects only by means of light that comes from them to your eyes. Light travels in straight lines. It goes through empty space, through certain substances as glass and air, but not through everything. Dust, mist, cloud, water, and solid earth either dim the light or shut out all of it. Air surrounds the earth, and the atmospheric ocean at the bottom of which we live is more than 100 miles deep; but the clouds, mist, and dust are most abundant in the lower 10 miles of the atmosphere. Light coming from a body near the horizon, in order to reach our eyes, must penetrate farther through the lower layers of the atmosphere than light coming from overhead.

Our eyes are affected by strong lights, so that they do not perceive dim ones at the same time. Twilight, moonlight, and artificial lights shining in our eyes make them less sensitive to very faint lights.

The earth rotates on its axis, carrying us with it. While it rotates it is also moving around the sun at the rate of about $18\frac{1}{2}$ miles a second. The time of a rotation is called a *day*, and the time it requires the earth to make a complete journey around the sun is called a *year*. These movements of the earth may be understood by certain experiments that any pupil can make for himself.

When a boy turns completely around, so as to face in all directions, he is rotating. When he walks around a tree, keeping at nearly the same distance from it, he may be said to revolve around it. If he were to rotate and revolve at the same time, his motions would be like the motions of the earth. If the boy who is both rotating and revolving will notice, at the time he is facing the tree, some distant object in line with it, and then when next facing the tree will look at the same distant object again, he will see that it is no longer in line. This will enable him to understand why the stars change their position with reference to the sun all through the year. Each night they rise about 4 minutes earlier than on the preceding night.



FIG. 132. On the moon a boy could lift 6 times as much as he can lift on the earth. Can you explain why this is the case?

CHAPTER NINE

THE SUN

O sun! that o'er the western mountains now
Go'st down in glory! ever beautiful
And blessed is thy radiance, whether thou
Colorest the eastern heaven and night-mist cool,
Till the bright day-star vanish, or on high
Climbest and streamest thy white splendors from mid-sky.

BRYANT

OUR life depends upon the sun. It is the source of light, heat, and power. Moonlight is but reflected sunlight, and if the sky were packed full of moons they would not afford us as much light as comes to us directly from the sun. The light that reaches us from all the stars is not nearly the millionth part of the light that comes to us from the sun. We get some heat from the interior of the earth, but it is not a thousandth part of what we receive from the sun. When the sun is absent for a night, the air becomes cooler; and if it were to be totally eclipsed for a week, all parts of the earth's surface would become cold.

Without sunlight green plants would not continue to grow. Animals then would soon be without food, for they cannot live indefinitely on one another. The fuel that we burn would not have been formed without the sun's rays to make things grow. Coal and gas were formed from the remains of plants that lived long ago. Even electric light and power are but transformed sunlight. No wonder that men in all ages have worshiped the sun.

The size of the sun. The sun is more than a million times as large as the earth. Its diameter is 866,000

miles, or nearly 110 times the earth's diameter, and the area of its surface is about 12,000 times the area of the surface of the earth. Can you think of anything so immense? Imagine the surface of the sun to be divided into states each the size of Ohio or Virginia. Now imagine a giant who at one stride could step from Boston to Albany; a second stride carrying him to Harrisburg, a third to Columbus, a fourth to Indianapolis, and so on. Let this giant begin visiting the states on the sun, spending but a minute in each state and never visiting the same one twice. If the giant begins at noon to-day, making a visit of a minute to each state, how long would it take him to visit all the states? Certainly 60 minutes would not suffice; would 60 years? The twentieth century would have passed before he could complete the task. You can readily calculate how long it would take him to make all his visits if you call the area of Ohio or Virginia 40,000 square miles and the area of the earth 200,000,000 square miles.

How we know the size of distant objects. Just as surveyors can calculate accurately the distance of a tree by sighting at it from the ends of a line, so they can determine also the height of a tower without going up on it, by measuring the angle formed by two lines directed, one toward its top, the other toward its base. They must know also the distance of the tower from the place from which they are viewing it. From Figure 133 it is obvious that the larger the object, the larger will be the angle made by the lines from the two ends of it.

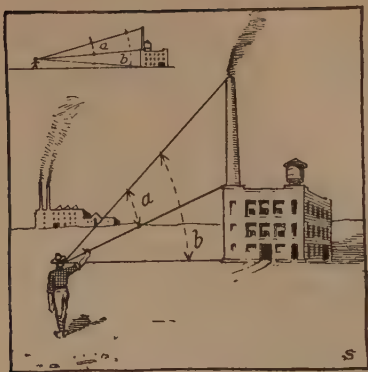


FIG. 133. Measuring the size of a distant object. By this same method astronomers, knowing the distance to the sun, moon, and planets, can calculate their size.

By this same method the astronomers can calculate the actual size of the sun, moon, and planets. They find the angle made by two lines running from opposite points on the edges of one of these bodies. Then, having already determined the distance of the body, they are able to calculate its size. This method cannot be used to determine the

size of the stars, for stars appear as mere points of light even when viewed with large telescopes.

Material of the sun. Astronomers are sure that iron, nickel, carbon, and many other substances that we are familiar with on the earth, exist also in the sun. The sun is so hot that even the iron in it is not solid or liquid but is in the condition of vapor. Substances in this condition occupy more space than they do when condensed to a liquid or solid; hence vapors are light. The sun in proportion to its size is only about one fourth as heavy as the earth. Ask a teacher of physics how we know what materials are in the sun.

Granular appearance and spots on the sun. The appearance of the sun is always changing; nothing seems to be fixed or solid. The surface appears granular,

as if covered with rice grains, but actually the grains are thousands of miles in diameter and of different shapes. Dark spots, that in reality are dark only by contrast with the more brilliant surface around them, are usually to be seen with a telescope or on photographs of the sun. Sometimes a spot is so large as to be visible if we merely look at the sun through smoked glass. Such a spot is much larger than the earth. The time when the spots are largest and most numerous is called a sun-spot maximum; when they are least numerous, the minimum. Sun-spot maxima occurred in 1883, 1894, 1906, and 1917. Large spots are often seen 2 or 3 years before or after the maximum. The interval, as may be seen from the dates given, is not uniform, but the average since 1610, when the spots were first observed, is 11.13 years. This interval is the same as that which intervenes between the greatest displays of the northern

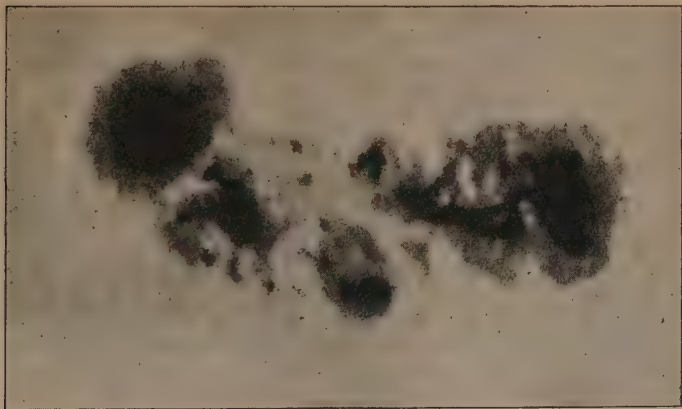


FIG. 134. Photograph of a great sun spot taken in February, 1917. The spot is 141,000 miles in length.

lights. There is also the same interval between the times when the earth's magnetism has the strongest effect on a compass needle. The connection between these facts and sun spots is not well understood. The sun emits a little less heat at times of sun-spot maxima.

Viewing the sun. The sun's light is so intense as to hurt our eyes if we look at it without something to obscure it, as a smoked glass. By holding a reading glass at the right distance from a wall or a sheet of paper you can throw upon the wall or paper an image of a candle, a window, or other source of light. In like manner, a large image of the sun may be thrown on a screen by means of a telescope. This instrument contains lenses similar to the reading glass. The image on the screen may be viewed without danger to the eyes. Another way to study the sun is by means of photographs. Much of what astronomers knew about the sun, until recent years, they learned by viewing it with telescopes at times of eclipses, when only the edge could be seen. Now they use many other instruments in studying it and much has been learned which you would think we could not possibly ever know in regard to a body that is 93,000,000 miles away. .

The cause of day and night. The sun is hidden from our view every night by the earth itself getting between us and the sun; yet it is always shining on the earth. If we could travel fast enough, we could keep in the sunlight all the time.

In ancient times people had no knowledge of the distance of the sun from the earth or of its size. It seemed

to them to go down into the western ocean and, some hours later, to come up in the east. We still say that the sun rises and sets.

When looking out of the window of a train at another train standing on a track at one side, have you ever found yourself unable to tell, when one of the trains started, whether it was the one you were on or the other one that was moving? The sun moves across the sky, from east to west, sets, and appears again in the east. How do you explain this apparent motion?

Eclipses of the sun. A total eclipse of the sun is an event long to be remembered. Around the sun may then be seen the beautiful corona and wonderful projections of light, like great tongues of flame, 5000 to 100,000 miles in length. Stars become visible, chickens go to roost, bats fly about, ignorant persons become terrified. Civilized peoples are able to predict when the darkening of the sun and moon will occur, but savages are always awed by the wisdom of the stranger who is able to foretell these events.

Frequency and duration of eclipses. Few persons witness a total eclipse of the sun more than once or twice in a lifetime unless they go purposely to the regions where astronomers have calculated that the eclipses will be total. Total eclipses may be seen oftener in the tropics than in high latitudes. Most persons in this country have probably never had an opportunity to witness a total eclipse of the sun; that is, to be where the moon completely hid the sun from their view. Seven total eclipses may be witnessed in the United States in the present century. One of them occurred on

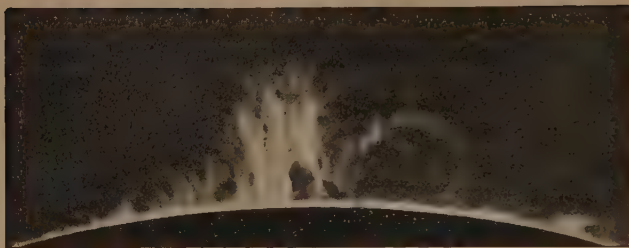


FIG. 135. Photograph of sun taken during an eclipse.

June 8, 1918, along a track from Oregon to Florida. Others will occur September 10, 1923; January 24, 1925; and August 31, 1932.

An eclipse of the sun remains total for less than 8 minutes, often for only 2 or 3 minutes. But the sun is partly hidden for an hour or two before and after the brief period during which it is entirely hidden.

Cause of eclipses of the sun. The sun is eclipsed by the moon passing between it and the observer. It may be eclipsed for observers at some places, while those on a distant part of the earth can see all of it. If it is totally eclipsed, it will appear so only to observers along a narrow belt of the earth. Those on either side of this belt will see a partial eclipse. You can understand why this is by using a globe to represent the sun and a smaller globe, or large ball, for the moon. You can get behind the smaller globe in such a way that it would prevent your seeing any part of the larger one. By moving slightly you can see a part of the large globe, and by moving farther, you can see all of it. Thus you see that to people differently located on the earth an eclipse of the sun appears different.

To observe solar eclipses and sun spots. Any of the following devices may be used in observing eclipses and sun spots:

(1) Expose a photographic plate to the light and then develop it, or hold a piece of window glass in a smoky flame. Either the fogged plate or the smoked glass may be used to protect your eyes.

(2) With a nail make a hole through a piece of tin which you can nail over a knot hole in a barn or other building. The sun's rays passing through the nail hole will form an image on a piece of white paper held in their path. Sunlight shining through a small hole in a curtain into a room that is rather dark may be similarly used to form an image.

(3) When the sun is partially eclipsed, punch a hole through a cardboard and observe the image on paper held in the path of the rays that come through the hole.

Questions about the sun. Why can we safely look

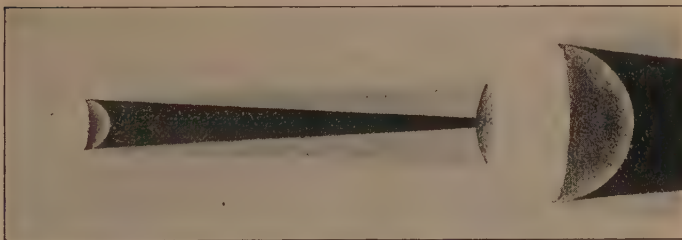


FIG. 136. Diagram to show an eclipse of the sun. The smaller body represents the moon, which is between the earth and the sun. Where the dark central shadow touches the earth the light is cut off from the entire disk of the sun, and in this area the eclipse is total. The part of the earth's surface covered by the wide lighter shadow is illuminated by light from a part of the sun, and in this area the eclipse is partial.

at the sun when it is close to the horizon? In what direction should we travel, and how fast, to prevent night from overtaking us? Where in America before the Spanish conquest was there a wonderful temple of the sun? Can you explain how electric light is transformed sunlight?

CHAPTER TEN

THE MOON

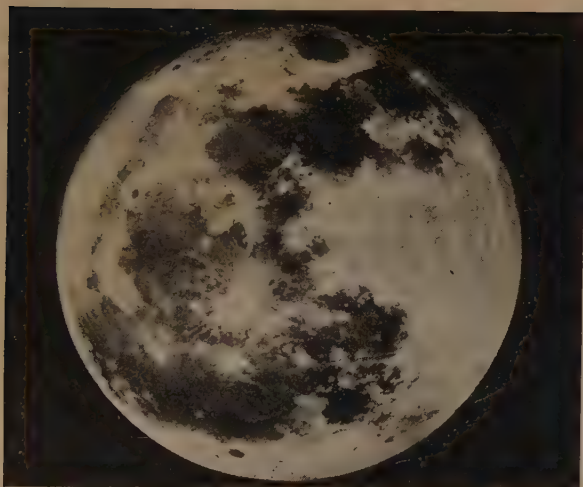


FIG. 137. The full moon as seen through a telescope.

FROM early times the moon has been contemplated with feelings of wonder and awe. Formerly many persons believed that certain crops must be planted in the proper phase of the moon or they would not yield well, and it was commonly held that sleeping in the moonlight affected the mind. Many superstitions regarding the mysterious powers of the moon are still current, but with the growth of knowledge these beliefs are rapidly dying away.

Now that we have such strong artificial lights we are not so dependent as formerly on the moon for the illumination of our city streets or for light when we wish to work late on the farm or take a journey at night, and

as far as we know neither the moon nor any of the planets can affect the weather. Yet the moon is, the chief cause of the tides, it affects the earth's magnetism as it moves about its orbit, and many a night is made more cheerful by the radiant beams from Luna's face.

Size of the moon and the distance to it. The diameter of the moon is 2163 miles, which is a little more than one fourth the diameter of the earth. It is much nearer than any other heavenly body to the earth. Its average distance is about 238,840 miles, but as its orbit is not a perfect circle it comes within 222,000 miles of the earth at one point, in each revolution, and at another point is about 253,000 miles away. Do you suppose that any man has in the course of his life walked as far as 222,000 miles? Has any one ever traveled so far?

How the moon looks when viewed with a telescope. As the moon is so near to us, its surface can well be seen



FIG. 138. A photograph of a part of the moon's surface.

with telescopes, and many details have been made out. Prominent markings, like craters, supposed by some observers to have been the vents of volcanoes long since extinct, are numerous. Some of them are much larger than any craters on the earth. From these radiate straight lines, in some cases hundreds of miles long. These "rays" are usually 5 to 10 miles wide and not much higher or lower than the moon's surface on either side. There are also "clefts," deep and narrow, running straight through mountain and valley for hundreds of miles, and "rills" — deep, narrow, crooked valleys. It is not easy to explain the origin of all these markings.

On the whole, the surface of the moon is much more rugged than that of the earth. Mountains are more common and some of them are higher than any on the earth, excepting those of central Asia. This seems the more remarkable when we consider that the moon is very much smaller than the earth. Its whole area is less than that of Asia. Its flat parts were named seas at a time when they were supposed to be bodies of water; but we now know that water does not exist on the surface of the moon unless it be in very small quantities. The "seas" are really plains. Clouds are never seen.

Part of the moon's surface never seen. Luna always faces the earth as she goes around it. Therefore we can never see her back, which is turned away. Forty-one per cent of the moon's surface has never been seen by any one on the earth. What that part is like we may imagine, but we do not know.

Conditions that would affect life on the moon. The moon has no atmosphere surrounding it. How do we

know? When the moon passes between us and a star, the star would become dim before disappearing if the moon were surrounded with air. Instead of that, the star remains bright until the instant it vanishes.

The moon must be made of material that is not very dense, for the whole earth weighs about 80 times as much as the moon, although it is only 49 times as large. We know this because the moon's power to attract other bodies is so much less than the earth's attractive force. A boy who weighs 100 pounds on the earth would weigh $16\frac{2}{3}$ pounds on the moon; and a baseball could be thrown 6 times as far as on the earth.

Every part of the moon is successively turned toward the sun as the moon revolves around the earth. As sunshine on the moon is continuous at any one place for about 354 hours, the temperature must become very high. Probably the rocks are heated to such a degree that they would burn you, if you were to touch them. During the equally long night the surface of the moon becomes very cold. The great change of temperature due to such long days and long nights is made all the greater by the lack of an atmosphere that would act as a shield against great extremes of heat and cold. Up high among the mountains on the earth where the air is rare, the difference in temperature during the day and the night is much greater than at lower levels.

How the earth would appear from the moon. If people lived on the side of the moon which we see, the earth would be visible to them all the time. It would never rise or set, but could always be seen in nearly the same direction and at nearly the same altitude, like the

North Star in our sky. To the inhabitants of the moon the earth would be like a very large moon and would show changes of form, depending on the direction of the sun, just as the moon does to us. When seen in the opposite direction from the sun, it appears full; and when in the same part of the sky as the sun, it is like a crescent. People on the moon would, however, see all parts of the earth as it turns on its axis. The same part would change appearance with changes of weather. Our country would sometimes be almost covered with clouds; at other times it would be almost free from them. When it is winter in the northern hemisphere, the extensive mantle of snow would afford more light to the people on the moon than they would get from the earth in July.

Questions for study and thought. When does winter come in our southern hemisphere? If viewed from the moon, would there be the same extent of snow-covered surface then as when there is winter in the northern hemisphere? What parts of the earth would look green at times? What parts would be green all the time? When the moon looks red, is it near the horizon or high up in the heavens? What makes it red? What do you think about the probability of life on the moon? Have you noticed the moon's position among the stars on two successive nights? About how many degrees, or what fraction of a circumference, does it move among the stars in 24 hours? Does it move east or west? Does it rise earlier or later each night than the night before? How many minutes earlier or later? Is the interval uniform?

CHAPTER ELEVEN

PHASES OF THE MOON AND ECLIPSES

When, as the garish day is done,
Heaven burns with the descended sun,
'Tis passing sweet to mark,
Amid that flush of crimson light,
The new moon's modest bow grow bright,
As earth and sky grow dark.

BRYANT

EVERY one must have noticed the moon's phases. When people had no better light at night than moonlight, they kept track of the moon from night to night more closely than we are likely to do now. Can you tell how often we have a new moon? In what direction is it? Which way do the horns point? Did you ever see a star between the horns? It is remarkable that so many intelligent persons have failed to understand the cause of the moon's change in aspect. When once understood the explanation is not likely to be forgotten.

Why the moon seems to change its shape. The moon shines only by reflected light; it is not self-luminous like a ball of fire or a star. Place a light-colored ball in the sunlight and view it from different positions. You will see that the bright part may be a circle, a semi-circle, a crescent, or some intermediate form, according to your position. The part of the ball which is not bright may show plainly without receiving light directly from the sun, because various things around are reflecting light to it. The moon out in space has nothing near it to throw light upon it, and so only the part that receives light directly from the sun is likely to be seen. If you are where you can see all the surface that is getting sun-



FIG. 139. The old moon in the new moon's arms.

light, the moon looks like a circle or globe. If half of the illuminated portion is turned from you, the remainder looks like a semicircle. If most of the illuminated portion is turned from you, the remainder looks like a crescent. Will this be the case when the moon and sun are in nearly the same direction from you or in opposite directions? Remember that the sun is always much farther away than the moon.

If you see the full moon in the evening, in which direction is it? Why? Do you ever see it in the morning? These are important questions.

The old moon in the new moon's arms. When the moon appears as a bright crescent, you can sometimes dimly see the outline of the entire circle. This is called "the old moon in the new moon's arms." The part that is dim is getting light from the earth. Otherwise you would not see it at all. This light has come from the sun to the earth, from the earth to the moon, and then back to your eyes.

When the moon appears to us as a crescent, the earth, seen from the moon, would appear to be in what phase?

When the moon is full, what phase would the earth be in? In what phase does the earth give most light to the moon?

Just as we receive more light from the full moon than from the crescent moon, so the orb on which we live sheds more light upon the moon when its illuminated half is turned toward the moon. Then is the time to see "the old moon in the new moon's arms."

Cause of the eclipses of the moon. The sun never comes between the moon and the observer. Eclipses of the moon are not produced by any heavenly body getting in our way so as to prevent us from seeing the moon, as the moon at times prevents us from seeing the sun. Lunar eclipses are produced by the earth itself getting between the sun and the moon, thus shutting off sunlight from the moon. Since the moon gives off no light of its own, it appears dark when the sunlight ceases to illuminate it.

When the moon is eclipsed, the eclipse can be witnessed from any part of the earth which is not turned away from the moon or covered with clouds, and will appear the same, no matter from what point it is seen. If it is a partial eclipse, then people on various parts of the earth will see a part of the moon illuminated by the sun. If the eclipse becomes total, the moon will be wholly shaded, no matter what the position of the observer. To represent an eclipse of an imaginary moon, you should first have a ball illuminated by light coming from one direction only. Can you produce either a total or a partial eclipse? Does the position of the observer make any difference?

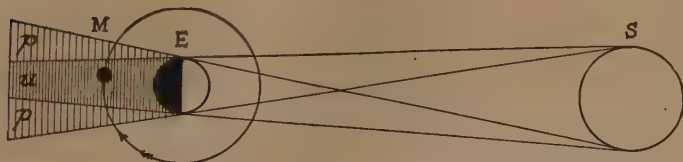


FIG. 140. Diagram showing an eclipse of the moon. The eclipse is caused by the earth's coming between the moon and the sun.

Eclipses of the moon sometimes continue total for about 2 hours. From the beginning to the end of the eclipse may be twice as long a time. Almost every year you have an opportunity to see one or two eclipses of the moon without going away from home.

Questions about eclipses of the moon. What color is the moon when in eclipse? Does it become wholly invisible? Why? Is the new moon ever eclipsed? Why? When the moon is partly eclipsed, the line separating the dark from the light part is always curved; does this fact give any evidence as to the form of the earth? Why does the sun never come between the moon and the observer? Why do not eclipses occur every time the moon goes around the earth?

CHAPTER TWELVE

THE PLANETS

PLANETS are very much nearer to us than the stars, for which reason more is known about them. Viewed with a telescope, a planet shows a disk instead of a mere point of light. With the naked eye it may often be distinguished from a star by its steady light. It does not twinkle like the stars except when near the horizon. All the planets are confined to the belt of the heavens traversed by the sun. You will never see any of them in the northern sky or much lower in the south than you see the sun in winter, for they revolve around the sun in orbits that lie nearly in the ecliptic or plane of the orbit of the earth. The most important observation you can make regarding the planets is that they change their apparent position among the stars from week to week, whereas the real stars keep their same position so far as you can see. The moon and sun were classified as planets in ancient times because they, too, move among the stars.

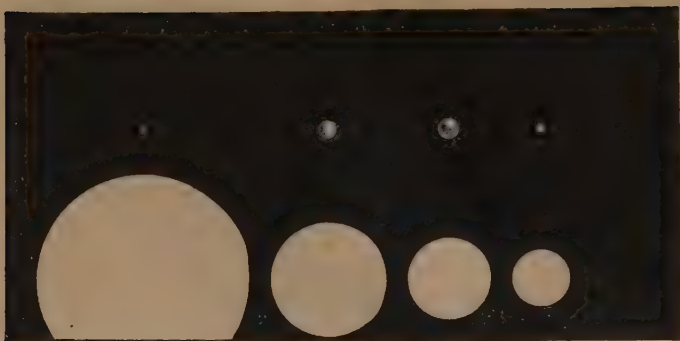
Size and motion of the planets. In the order of their distance from the sun, the eight major planets are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Of the first four, the earth is the largest, but each of the second four is very much larger than the earth. Jupiter, the largest, is about 1300 times the size of our globe.

Mercury moves about the sun in an ellipse much smaller than the orbit of the earth and requires but 88 days to complete a revolution. In other words, its year is less than one fourth of ours. Neptune, which

has the longest orbit of all the planets, requires 165 years to complete a revolution; the other planets have periods between these extremes, according to their distance from the sun. If you will watch Jupiter year after year, you may see that each year it moves among the stars about 30 degrees, or about one twelfth of the whole way around. Its period of revolution is not quite 12 years. If you see it in a certain direction this year in October at eight o'clock, next year you will see it in the same position at eight o'clock in November and the following year in December; thus in 12 years it will have made a complete revolution in the heavens.

By taking hold of a string that is attached to a ball, you can whirl the ball around your hand in any direction you please. You can imagine eight balls without strings whirling around your hand at different distances. They might all whirl in the same direction or they might have quite different directions, one moving in a north-and-south plane, another east and west, others in planes inclined at large angles to both of these. If your hand were touching the floor the balls might roll in circles of different size, all the circles having your hand as the center. They might all go one way around, or some one way, others the opposite way.

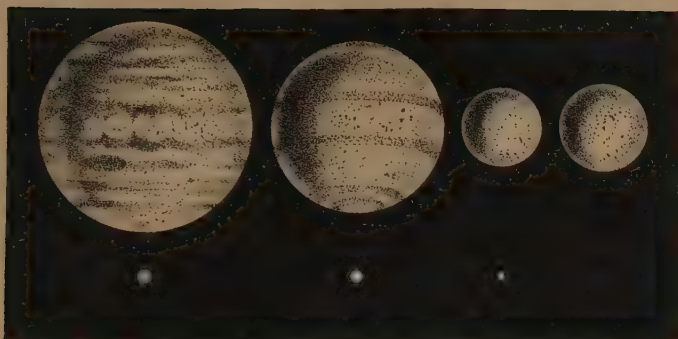
The eight planets revolve around the sun almost in one plane, and they all revolve in one direction. The earth is one of them, and the plane in which it moves is called the *plane of the ecliptic*. The planes in which the others move are inclined only a little to the plane of the ecliptic. It would be useless to try to find a planet anywhere in the heavens except near the ecliptic.



FIGS. 141 and 142. The upper row shows the relative sizes of the planets, the

Tracing the ecliptic. The sun is always on the ecliptic. If it were to leave a trail in the sky to show where it had been, this trail would mark the ecliptic. In summer the sun rises to the north of east, is high in the south at noon, and sets north of west. In winter it rises south of east, is not very high above the southern horizon at noon, and sets south of west. As it leaves no trace, we need to keep in mind the path it seems to follow in order to locate the ecliptic. At night in winter the part of the ecliptic we can follow across the sky is the part which the sun traversed in the daytime in summer. This part is higher above the southern horizon than that part of the ecliptic which we are able to trace on a summer night. The moon is never more than 5 degrees and 8 minutes from the ecliptic.

Why a planet's brightness changes. The planets, unlike most of the stars, change in brightness. For weeks or months a planet becomes less bright, then gradually regains its brilliancy. This is due to several



lower row the comparative sizes of the sun as viewed from each of the planets.

causes, but mainly to the varying distance from the earth.

From Figure 143 it is evident that the distance between Earth and Mars is much less when both planets are in the same direction from the sun than when one is on one side of the sun and the other on the other side.

How to distinguish one planet from another. The three brightest planets, if no others, should become familiar to you so that you can recognize them as you do the moon and the sun. Venus, when brightest, gives us more light than any other heavenly body except the sun and the moon. Look for it in the west after sunset, or in the east before sunrise. When Jupiter is in the eastern sky in the evening, it is unsurpassed in brightness by any other heavenly body in that part of the heavens, unless the moon happens to be there, too. Mars, when in the east in the evening, is brighter than any fixed star. It may be known from Jupiter by its red color.

Two other planets were known in ancient times: Mercury, which is always near the sun, — most of the



FIG. 143. Diagram showing Mars at its greatest distance and least distance from the earth.

time too near to be seen, — and Saturn, which is as bright as a first-magnitude star. Uranus and Neptune are so far away that they never appear bright, Neptune being quite invisible to the naked eye.

In the chapters that follow, where the planets are described, there is a list of dates showing when each can best be seen.

CHAPTER THIRTEEN

MERCURY AND VENUS

MERCURY and Venus are the only planets that are nearer to the sun than the earth is. They never appear very far from the sun. Sometimes one or the other of them passes directly between us and the great orb of day. It then appears as a dark speck on the brilliant surface of the sun.

Mercury. Since Mercury is always so near the sun and is not bright enough to be seen in the daytime, it is visible only low in the west a short time after sunset or in the east just before sunrise. When the sun is not far below the horizon, its light is still so strong as to prevent our seeing the stars. A little later the brightest stars come into view. If Mercury is still well above the horizon and the sky is very clear, this planet may then be plainly seen where the sun was an hour or more before. The astronomer Copernicus, who lived near the Baltic Sea, never saw Mercury because the mist near his horizon always shut out so faint a light. In America we have clearer skies, and if you look for Mercury at about the time when it is farthest from the sun you will probably find it. If any bright stars happen to be low in the west where you are looking for Mercury, you can tell them from the planet by noticing that they twinkle more.

While Mercury never appears to be far from the sun, its actual distance ranges from 28,500,000 to 43,500,000 miles. As these figures show, its orbit is not much like a circle. Of all the planets, Mercury has the swiftest motion in its orbit — 23 to 35 miles a second; the slower motion is when it is farthest from the sun. It is the

smallest of the eight major planets, with a diameter of only 3000 miles. Its year is 88 days in length and it

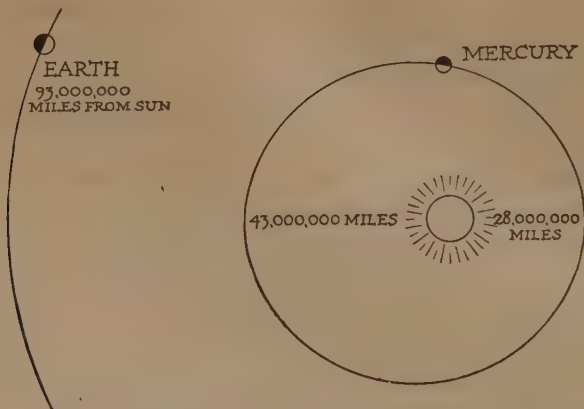


FIG. 144. Diagram showing the orbit of Mercury. Since Mercury is always near the sun, it is visible only low in the west a short time after sunset or in the east just before sunrise.

rotates on its axis in the same time, so that the same side is always turned to the sun.

Mercury will be farthest from the sun as evening star on March 21, July 18, and November 12, 1919, and at intervals of 116 days thereafter.

~~V~~**Venus.** Venus is almost as large as the earth and has been called the earth's twin sister. It is the bright star you have heard called "the evening star" or, when seen before sunrise, "the morning star." At times other planets attract attention as "evening stars" or "morning stars," but they are not so bright as Venus.

Venus is larger than Mercury and much of the time is higher above the horizon after sunset or before sunrise.

For both these reasons she is more often seen. Her brightness is due also to the fact that her surface reflects much of the sunlight that strikes it, just as light wall paper reflects more light than dark wall paper. Venus is so bright that she has often been seen in the daytime. When evening star, she may be plainly seen after sunset where the sun was 2 or 3 hours before.



FIG. 145. Venus showing crescent phase. Like the moon, Venus shows all phases, from a narrow crescent to a full disk.

For periods of several months you cannot see Venus in the evening because she goes down below the horizon before the sun does. She will then rise before the sun and may be seen in the east early in the morning. When changing from evening to morning star and, $9\frac{1}{2}$ months later, from morning to evening star, Venus is so near the sun for a few weeks as to be invisible on account of the superior light of the sun. Venus as evening star will be farthest from the sun on July 4, 1919, February 1, 1921, and September 18, 1922, and as morning star about $9\frac{1}{2}$ months earlier or later than these dates.

Venus is 67,000,000 miles from the sun. At times she approaches to within 25,000,000 miles of the earth, but her dark side is then toward us, for only the side toward the sun is illuminated. Apparently the planet is enveloped in clouds, so that no permanent markings are visible even with large telescopes. Venus's year is 225 days long. Like Mercury, the planet always

turns the same side to the sun, and therefore there is no succession of days and nights.

To see Venus in the daytime. In order to see Venus while the sun is above the horizon you must be in the shade and must know just where to look. Proceed as follows :

(1) When Venus is an evening star, note the time of setting of the sun and the time of setting of Venus. Note whether Venus sets north or south of the place where the sun sets.

(2) As the majority of roads and streets have been laid out either north and south or east and west, the majority of buildings have walls running in these directions. A wall that runs north and south is in the plane of the meridian. At twelve o'clock, sun time, stand at the northeast corner of a large building where its shadow will touch you. Notice carefully on the building the direction of the sun just before it is hidden from your view. After a while Venus will be in this same direction from you if you are then in the same place as at twelve o'clock. The planet will be on the meridian about the same number of minutes later than the sun as it was later than the sun in setting; it will be somewhat higher in the sky, if it sets north of the sun; lower, if it sets south of the sun. |

When Venus is a morning star rising 2 hours and 20 minutes before the sun, at which corner of the building should you stand in order to see the planet in the daytime? When would it be on the meridian?

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CHAPTER FOURTEEN

MARS AND THE MINOR PLANETS

MARS is sometimes brighter than any star or any other planet except Venus and Jupiter. It comes next after the earth, as we name the planets in the order of their distance from the sun, and is at times comparatively near to us. It is for this reason that it seems bright. In size it is surpassed by all the major planets except Mercury. Its diameter is 4200 miles, and its mean distance from the sun 141,000,000 miles. It revolves around the sun in 687 days.

Distance of Mars from the earth. When the sun and Mars are in the same direction from the earth, the distance of Mars from the earth is equal to the sum of the distances of the two planets from the sun (Fig. 139). Mars is then $141 + 93 = 234$ million miles away. When Mars and the sun are in opposite directions from us, so that one rises as the other sets, the distance of the planet from the earth is $141 - 93 = 48$ million miles. If the orbits were exactly circular, Mars would never be nearer to us than this, but Mars's orbit deviates from a true circle more than do the orbits of most of the planets. Once in about 17 years it comes within 36 million miles of the earth. As the side turned toward us is then fully illuminated, it may be viewed more satisfactorily with a telescope than any other heavenly body except the moon. Venus comes nearer to the earth, but at such times always turns her face away from us.

It will be seen that Mars's least distance from the earth is about one seventh of its greatest distance. As 49 candles at a distance of 7 yards afford no more light

than 1 candle at 1 yard, so Mars, when nearest, would give us 49 times as much light as when farthest away, supposing that it were equally illuminated by the sun in both cases.

Mars will rise in the east at the same time that the sun sets in the west, on May 10, 1920, and July 4, 1922. On any clear night for weeks before or after these dates, Mars may be seen as a bright red star.

Satellites of Mars. Mars has two satellites, Phobos (Fear) and Deimos (Fright). These revolve around Mars as the moon goes about the earth. They were discovered in 1877 by Professor Hall, using the great telescope of the Naval Observatory at Washington. So small are they that their size cannot be measured, but must be merely estimated from the amount of light they give us. The smaller one, Deimos, is perhaps something like 10 miles in diameter. Seeing it at a distance of 35 million miles is like seeing a baseball at a distance of 200 miles, which is farther than from Washington to New York. The larger satellite, Phobos, is about 3650 miles from the surface of Mars and completes a revolution about the planet in 7 hours and 39 minutes. As Mars requires 24 hours for a rotation, this satellite goes around it one and a half times before the planet turns halfway around, so that the inhabitants of Mars, if it has any, would see this little moon rise in the west, cross the sky, set in the east, and a second time rise in the west, all in the course of one night. Although a tiny object as compared with the rest of the heavenly bodies we know, yet it is so close to Mars that

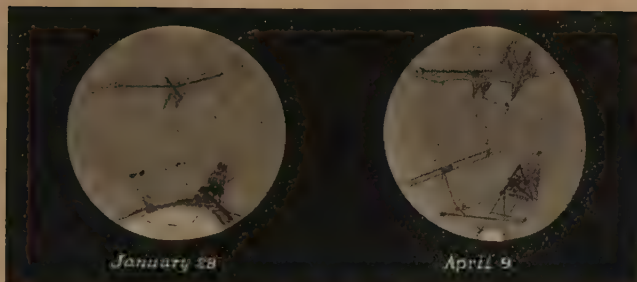


FIG. 146. Mars in 1916. Photograph of drawings made by Dr. Percival Lowell.

seen from there it might appear half as large as the moon viewed from the earth.

Is Mars inhabited? If any planets besides the earth are inhabited, Mars and Venus are probably the ones; for the others are believed to be either too hot or too cold for living things to exist on them. Even when nearest to us, Mars's distance is too great for us to see upon the planet, with the very best telescopes, so small an object as the largest of our living creatures—an elephant or a whale. Even the largest building in the world could not be seen at such a distance. Yet things have been seen on Mars which some astronomers consider the result of the work of intelligent creatures.

The equator of Mars is inclined to the plane of its orbit 24 degrees and 50 minutes, so that it should have seasons just as the earth has. When its north pole is turned away from the sun, that part of the planet becomes covered with a white substance, which has been supposed to be snow or ice. This cap shrinks on the coming of the Martian spring, and then lines may be

seen extending from it toward the equator. These lines were thought by the astronomer Percival Lowell to be strips of green vegetation bordering streams of water so straight that they must be canals constructed by human beings.

On the other hand most astronomers, even when provided with very large telescopes, are unable to see anything that convinces them that Mars is inhabited. It is so far from the sun that unless it has a supply of heat of its own, snow would probably not melt in the spring. Possibly the whiteness may be due to frozen carbon dioxid or some other substance which melts at a lower temperature than snow.

THE MINOR PLANETS

Early in the nineteenth century four minor planets, or asteroids, were discovered, and nearly 900 are now known. The ones first discovered are probably between 100 and 500 miles in diameter; those recently discovered are only 10 or 20 miles in diameter. All of them put together would make a planet only a small fraction of the size of the earth.

Like the large planets, the minor planets go around the sun, but in orbits that are more eccentric. That is, their paths are not so much like circles. One minor planet, Eros, revolves about the sun in an orbit which at one point is only 13,500,000 miles outside the earth's orbit. The paths of almost all the others now known lie between the orbits of Jupiter and Mars.

There are probably many hundreds of minor planets which have not yet been discovered. Of late years,



FIG. 147. Photograph showing the trails of two minor planets. The telescope was set to move with the stars, and the images of the planets show as streaks on the plate.

the discovery of new ones has been made easier by photography. In a large photographic telescope a plate is exposed for several hours. If the telescope were motionless it would keep pointing farther east among the stars as the earth rotates, but clockwork is arranged to counteract this motion, causing the instrument to move to the west as fast as the stars do. When the plate is developed the stars appear as points, but the planets as streaks, for they moved while their pictures were being taken. Of late years astronomers have reversed this by making the telescope's motion conform nearly to that of the average minor planet, so that the stars, instead of the planet, show on the photograph as streaks.

CHAPTER FIFTEEN

THE OUTER PLANETS

IN several ways the planets Mercury, Venus, and Mars resemble the earth, and hence these four are known as the *terrestrial planets*. Outside the orbits of Mars and of the minor planets, four great worlds, many times larger than the earth, revolve about the sun. These are the planets Jupiter, Saturn, Uranus, and Neptune.

The years of these outer planets are longer than the years of the planets we have studied because they have farther to go in their revolution about the sun and their motions along their orbits are slower. Thus the earth moves $18\frac{1}{2}$ miles a second through space, while Neptune moves only $3\frac{4}{10}$ miles a second. In proportion to their size the outer planets are much less dense than the terrestrial planets. The earth, taken as a whole, is more than $5\frac{1}{2}$ times as dense as water. Saturn is lighter than water, and Jupiter, the densest of the four outer planets, is only $1\frac{1}{8}$ times as heavy as water.

The four terrestrial planets together have only three satellites, two of them so small that no telescope would reveal them if they were as far away as Jupiter. Twenty-three moons belonging to the four outer planets are now known, and it is probable that they have other smaller satellites which have not been seen.

JUPITER

The diameter of Jupiter is about 86,500 miles. It is 1309 times as large as the earth and contains 317.7 times as much material. It will rise as the sun sets

on January 1, 1919, and about one month later with each succeeding year.



FIG. 148. Jupiter in conjunction and in opposition.

Jupiter's year is about 12 times as long as our year. This great planet rotates on its axis in 9 hours, 55 minutes, so that the time between sunrise and sunset there is less than 5 hours and we should have to hurry to accomplish a day's work before sundown. Moreover, hurry on Jupiter would be difficult, for a man who weighs 150 pounds on the earth would weigh 400 pounds on Jupiter. There you could not jump half as high as you can here.

Possibly if you were on Jupiter you would find nothing to stand on or lie on, for all that can be seen from the earth is cloud. It may be that the whole planet, like the sun, consists of gases, vapors, and mist, which are hot, although the intensity of the heat received from the sun at that distance is only $\frac{1}{27}$ of what it is at the earth's distance. It is probably not so hot as to emit any light of its own. We see it as we do other planets, by means of reflected sunlight. Its brilliancy is due both to its large size and to its high reflecting power, for, like a bright cloud, it reflects more light than does

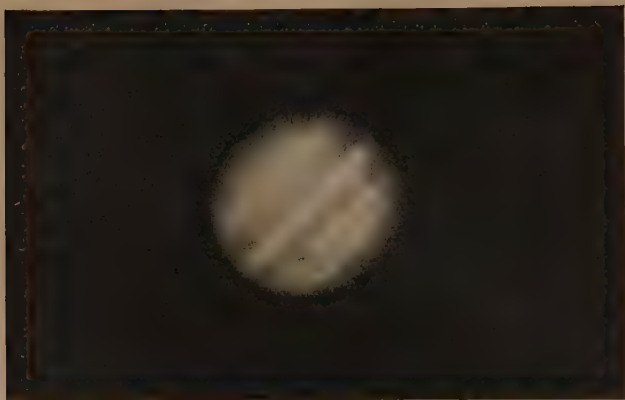


FIG. 149. A photograph of Jupiter.

dark earth or rock. Do you think there was ever a time when there was nothing solid about the earth?

Satellites of Jupiter. The first heavenly bodies discovered after the invention of the telescope were four satellites of Jupiter. They are farther from Jupiter than our moon is from the earth. The smallest of them is about the size of our moon. With field glasses you should see them. Perhaps only three will be visible at the time you look, the other being behind or in front of the great planet, so that it does not show; or two of the satellites may be so close together that they will appear as one. The satellites seem to be close to the planet and in a straight line. Besides these four satellites Jupiter has five others, so small that they were not discovered until recent years, and possibly some that have not yet been seen by any one on the earth.

It is quite improbable that anything could live on Jupiter, but some of its four large satellites may be

suitable for habitation, although we have no evidence that any creatures actually live upon them. If intelligent beings inhabit any of them, they enjoy moonlight from several of the other moons at all times. Jupiter itself would give them both light and heat, and would seem to them much larger than the sun appears to us, although less brilliant. The little satellite discovered at the Lick Observatory in California in 1892 is less than 70,000 miles from the surface of Jupiter. Other faint satellites are more than 6,000,000 miles away. The most distant one revolves around Jupiter from east to west, while the rest of them revolve in the direction in which Jupiter rotates, from west to east.

SATURN

Saturn, when nearest to us, looks like one of the brightest stars. As it takes $29\frac{1}{2}$ years to go around the sun, it moves among the stars only about 12 degrees a year. Having once located it, therefore, we can find it at the same month of the following year near the same place, only a little farther to the east. In December, 1917, it was low in the east early in the evening, and for several years following 1917 it will be seen in the same direction in winter, appearing later in the evening or later in the season as the years advance. On January 31, 1918, it rose as the sun set, and it will rise at sunset about 13 days later each succeeding year.

Viewed with a telescope, Saturn, like Jupiter, is seen to be enveloped in clouds. At such a distance from the sun these clouds would condense into liquid or solid substances unless they were receiving heat from the

planet itself. Both Saturn and Jupiter may be so hot that they consist entirely of vapors. Saturn is nearly 800 times as large as the earth and only 95 times as heavy, with a density only one eighth that of the earth.

Satellites of Saturn. Saturn has eight moons that have been known for a long time. A ninth one was discovered in 1899 on a photograph taken the previous year at the Harvard Observatory at Arequipa, Peru, by Professor W. H. Pickering, who named it Phœbe. To see so small an object at such a distance is like seeing from the National Capital a humming bird in Central Park, New York.

Saturn, like the earth, rotates from west to east, and most of its moons revolve about it in the same direction; but Phœbe, the most distant of its satellites, revolves from east to west.

Rings of Saturn. More wonderful than its moons are the brilliant rings that surround this planet. These may usually be seen with a small telescope, though at times a large one is required to make them visible. Galileo, who saw them in 1610 without understanding

what they were, was much puzzled; for when he looked for them a while afterward he could not see them at all. The explanation is simple. The rings are flat, like a sheet of paper or cardboard: when the sides of the

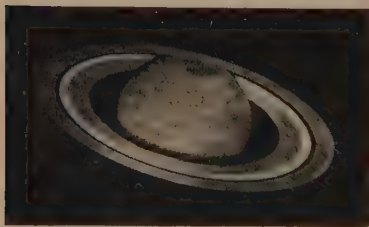


FIG. 150. A photograph of Saturn showing the rings turned partly toward the earth.

rings are turned toward us, we see them; when the edges are turned toward us, the rings disappear.

The outer ring of Saturn is 176,000 miles across; the planet itself has a diameter of 74,000

miles. The inside of the inner ring is less than 10,000 miles from the surface of the planet. Of the three rings, the middle one is much the broadest, having a breadth (not diameter) of 17,000 miles. The thickness of the rings is probably not over 100 miles. They are not continuous sheets, but consist of separate particles, probably meteorites, pursuing their orbits like a swarm of little moons around the planet. What a wonderful sight should we find Saturn with its rings and moons, if we were only on one of them!

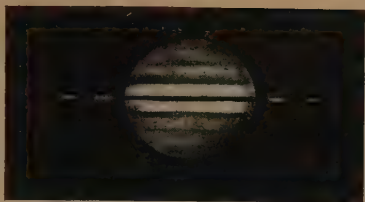


FIG. 151. Photograph of Saturn with the rings turned edgewise to the earth.

URANUS

The planet Uranus was discovered by Sir William Herschel in 1781. He was looking for interesting objects in the sky with a telescope he had himself constructed. Happening to direct it toward Uranus, he saw at once that this was not a star, for it had some breadth instead of appearing as a mere point of light. For a time he thought it was a peculiar sort of comet.

Uranus requires 84 years to complete its revolution around the sun. It is about 30,000 miles in diameter and may be seen by a good eye without the aid of a telescope.

Even when viewed with a large telescope it does not show plainly any markings such as are seen on Mars, Jupiter, or Saturn.

Satellites of Uranus. A few years after his discovery of Uranus, Herschel found that it had two satellites. Later two others were discovered. All of them are small. They revolve around Uranus in different periods, the one most distant from the planet requiring nearly $13\frac{1}{2}$ days to complete a revolution, while the nearest satellite goes around 5 times in less than 13 days.

NEPTUNE

Neptune, the most remote of the planets, is about 60 times as large as the earth. If it were self-luminous like the stars, it would appear brighter than any of them, for it is very much nearer. But as it is seen only by reflected sunlight, and is so far away, it is visible only with a telescope or, possibly, with good opera glasses. No one had noticed it until 1846, when it was found within half an hour after the astronomers began to look for it. Why did they look for such a body and how did they know where to look? If a ball were lost in another state and you had no clew whatever as to what part of the state it was in, you surely would not undertake to find it.

It was the behavior of Uranus that set the astronomers to hunting for a new planet. Uranus was found to move in an irregular manner that could not be explained without taking into account the attraction of some body which had not been seen. A French astronomer, Leverrier, and a young Englishman named

Adams, each independently of the other, calculated the position of the unseen body which was influencing the motion of Uranus, and advised that it be looked for in this place. Few persons have ever solved so difficult a problem as this calculation involved. If you are pleased when you succeed in understanding something which for a time seemed beyond your power of comprehension, you can appreciate the feelings of these astronomers who, after working faithfully on a problem that seemed almost impossible of solution, could say: "Point your telescope in a certain direction [which they definitely specified] and you will see a world heretofore unknown."

CHAPTER SIXTEEN

SHOOTING STARS



FIG. 152. The trail of a meteor. The great nebula of Orion is seen in the background.

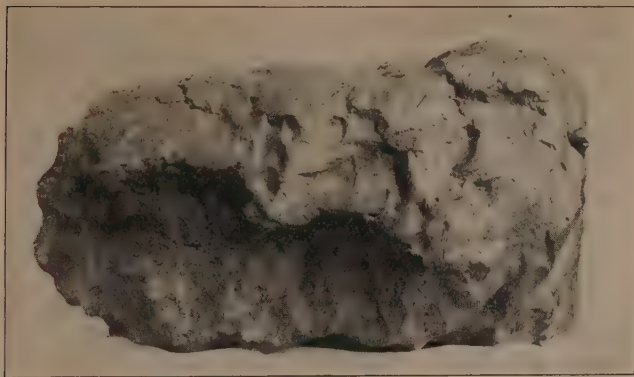
SHOOTING stars are no more like real stars than skyrockets are like the earth. They are small, dark bodies moving through space, and we do not see them until they enter the earth's atmosphere. Then the friction caused by their rapid motion through the air heats them so that they glow and are bright for an instant, and then disappear. On a clear night a number of shooting stars may be seen by observers on any part of the earth. As the same ones are not visible at stations far apart, the whole number entering the earth's atmosphere every 24 hours must be many millions, and they have probably been falling

in this number for many millions of years. Being so small, they burn out or are reduced to dust before reaching the solid earth, and cannot be distinguished from dust derived from other sources. By melting large quantities of snow in the arctic regions, men have obtained dust which they believed to have come partly

from shooting stars. Ooze from great depths in the sea far from any land is believed to be composed partly of dust from the same source, which has settled through the water and represents the accumulation of many thousands of centuries.

Meteors. A few shooting stars are much brighter than others. These are called *meteors*. They are likely to give off glowing particles forming a train, and the train sometimes remains visible for half an hour after the meteor falls. These brilliant meteors, as they pass through the air, often produce sounds, which have been likened to the detonations of explosives, the roaring of a fire in a chimney, the noise of a trolley car, the flapping of the wings of wild geese, and various other sounds.

Rarely it happens that meteors strike the solid earth and are picked up. They are then called *meteorites*. The great national museums at London, Vienna, Paris,



Oliver C. Farrington

FIG. 153. Iron meteorite found on Davis Mountains, Texas, in 1903.
Its weight is 1520 pounds.

and Washington have many specimens, as have the Field Museum at Chicago and the museums of Amherst, Harvard, and Yale; but the majority of small museums have none, although amateur collectors are likely to think that some of their peculiar-looking stones are meteorites. Only about 300 of the meteors which have fallen in the past 115 years have been found by any one, so far as we know. Some, however, have burst while passing through the air, giving rise to hundreds of fragments which have been picked up. Genuine meteorites are very interesting, because meteors are the only celestial bodies we know that ever come to the earth. Until about the beginning of the nineteenth century learned men were not convinced that stones ever came to the earth from a distance. Previous to that time reports of falling stones had given rise to much discussion, but they were explained as a consequence of thunderstorms or of volcanic eruptions.

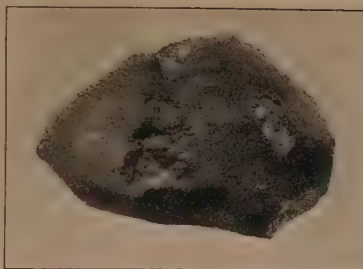
The motion of meteors. The rapid motion of a meteor when it first enters the air is unlike anything we have seen moving on the earth, but is like the motion of the earth itself in its course around the sun. Astronomers believe that the meteors before we see them are moving in long orbits about the sun and would continue so to move if the earth did not get in their way. Comets move around the sun in the same manner, and there are good reasons for believing that meteors were once parts of comets.

When first seen, meteors and shooting stars must be about 100 miles, or a little less, from the surface of the earth, because they are invisible until made luminous

by friction with the atmosphere. They move 10 to 45 miles a second; that is, 20 times as swiftly as a rifle bullet or 1000 times as fast as an express train. If not checked by the air, they would strike things on the surface of the earth with great force.

The few which pass through the atmosphere without being reduced to dust are moving much less swiftly when they strike. Some meteoric stones which fell in Sweden struck ice only a few inches thick and rebounded without breaking it. But one which fell in France on a beautiful summer day in 1872 struck with such force as to make a hole in the earth over 5 feet deep. It weighed 126 pounds. If found shortly after falling, the meteorite and the earth into which it has penetrated are likely to be cold; for the meteor, before encountering the earth's atmosphere, was colder than anything on earth, and only the superficial portion is heated by its brief flight through the air.

Star showers. On the night of November 12, 1833, the slaves on Southern plantations thought the world was coming to an end. Stars fell half as fast as snowflakes in an ordinary snowstorm. Humboldt, the famous traveler, describes a bright shower of meteors that he witnessed in South America in 1799. Professor



Oliver C. Farrington

FIG. 154. Meteoric stone which fell through the roof of a barn at Kilbourne, Wisconsin, January 16, 1911. Its weight is 2 pounds.

H. A. Newton of Yale wondered if such a shower might not have occurred many times before at intervals of 33 or 34 years, and by searching the records found this to be true. He predicted a meteoric shower for November 13, 1866, and his prediction was verified. In November, 1867, another shower occurred, much feebler than that of 1866, and in each following year the display was fainter and fainter. In November, 1901, there was a fairly good shower, but it was quite inferior to those previously mentioned.

Explanation of star showers. When a meteoric shower occurs, the paths pursued by the meteors, if traced back, all seem to lead to the same point. For the November meteors, the point is in the constellation Leo, and they are called *Leonids*. For the meteors which fall every year about the 10th of August the point is in the constellation of Perseus, and they are called *Perseids*. The meteors that fall in the same shower are all moving in the same direction in an orbit about the sun. The earth passes across this orbit at a certain time of the year. If the meteoric bodies are well distributed along this orbit, then we see them every year; if they are mostly in a swarm that takes 33 years to complete a revolution, then we shall see the greatest number once in 33 years, when the earth comes to the orbit at the time the swarm is passing.

Besides the Leonids and the Perseids, there are meteoric showers at other dates, one about November 23 and another in April, besides many that are too faint to attract much attention. By comparing the orbits of these groups of meteors with the orbits of certain

comets, astronomers have found some of them to be identical. A lost comet was shown to have had the same orbit as the meteors of November 23, which are known as *Andromedes* from the constellation of Andromeda, whence they seem to come. It is believed that these meteors once formed Biela's comet. Likewise each swarm or ring of meteors may once have been part or all of a comet. As the number of shooting stars which the earth encounters daily is several hundred millions, its mass must have increased from this source in the course of long ages. The same increase in weight from falling meteors must have taken place in the case of the other planets also.

CHAPTER SEVENTEEN

COMETS

IGNORANT persons have sometimes been terrified by the appearance of a comet, thinking it portended some great calamity, perhaps the end of the world. Those who view the heavens with telescopes have no fear of comets doing any harm, for they see one or more nearly every year, and sometimes more than one may be visible at a time. Only a few of the comets that astronomers study ever become bright enough to attract the attention of other persons. These comets become brighter and brighter night after night as they draw nearer to the sun. They do not strike the sun but pass sometimes very near it and, after going part way around it, go off into space again, gradually becoming fainter and fainter until they are no longer visible to the naked eye and finally not even with a telescope. The whole period of visibility is usually not many months, but in some cases it is more than a year.

The tail of a comet. Comets have a different shape from the other heavenly bodies and differ greatly even among themselves. Bright comets have a tail, which is somewhat curved and millions of miles in length. This is always directed away from the sun, as if the latter in some way repelled the particles of which the comet consists. After the comet in its motion has passed as near the sun as its orbit permits and is receding from the sun, the tail goes ahead instead of following, as it does when the comet is approaching the sun. In a few instances the length of a comet's tail has been greater than the distance from the earth to the sun.

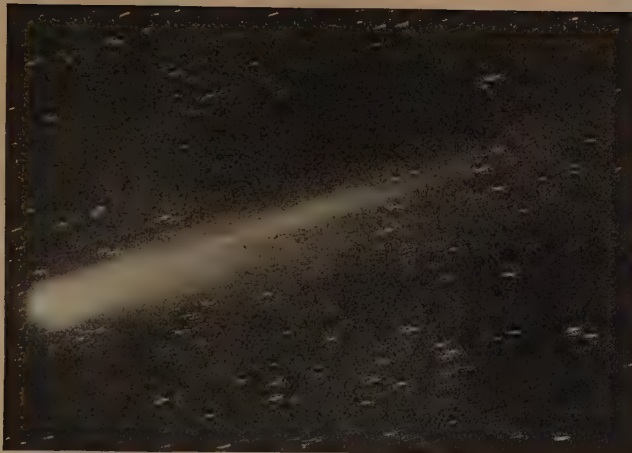


FIG. 155. Photograph of a comet. The telescope was set to move with the comet, and the stars show as lines on the plate.

On the 30th of June, 1861, the earth passed through a comet's tail. The light of the sun was somewhat obscured, so that artificial lights had to be used at seven o'clock in the evening, although the sky was cloudless. Yet the effect on the earth and its inhabitants was so slight that the vast majority of persons never knew that such an event had taken place.

The head of a comet. The head of a comet is not a single bright point like a star, but hazy, and keeps changing its size, usually becoming smaller as it approaches the sun and expanding again as it recedes. The head is often 40,000 or 50,000 miles in diameter, or half the diameter of the planet Jupiter, though not nearly so bright. Very few have been seen which were as broad as the sun and few that were bright enough to be visible when the sun was high above the horizon.

The orbits of comets. Comets disappear in the distance, but after years of absence some of them visit us again. As the same comet changes its appearance so much from time to time, it is not easy to tell whether a comet we see this year is the same comet that was seen years ago. The paths comets follow through the sky have been carefully studied by astronomers, who in this way have made out many different ones. Some have been found after a few years to return along the same path. Halley's comet returns only after a period of about 77 years, so that the same person is not likely to observe it twice. It was seen in 1681, 1759, 1835, 1910, and probably will appear again in 1986. An interesting point about the orbits of comets is that they move across the heavens in any direction, while the orbits of the planets lie only in an east-and-west plane.

The mass of comets. Although comets are large, we know that there is not much substance to them, for when they pass near a planet they never pull the planet out of its path, but the planet pulls them quite out of their course. Even the faint stars can be seen through the tail of the comet and through all but the densest part of the head. They are probably made up of numerous small bodies separated by relatively wide spaces that are filled with certain light gases. Probably the solid bodies are meteoric stones.

The great planets, like Jupiter and Saturn, not only alter the courses of those comets which happen to be passing near them but they sometimes separate the members of a swarm of small bodies so widely that they no longer appear as a comet. The swarm then continues

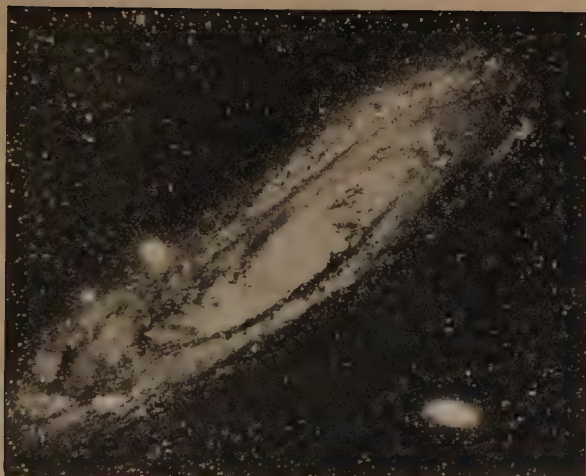


FIG. 156. Great nebula in Andromeda.

its motion around the sun, and becomes visible to us as a shower of meteors when the earth gets in its way.

Nebulæ. Nebulæ are like comets in appearing hazy, but they are not parts of the solar system. More than 100,000 nebulae can be seen with the largest telescopes. Probably none of them are as near as the brighter stars. Some are green in color, but a great majority are white and show a spiral form. These are believed to consist of innumerable small particles of solid matter and some gas. The green nebulae are thought to be mainly gaseous. The great nebula in Andromeda is the only one that is large and bright enough to be easily seen with the naked eye. The distance across it is probably hundreds of thousands of times as great as the distance from the earth to the sun. It is approaching the solar system at the rate of 185 miles a second.

A LIST OF BOOKS ON STARS

- Ball, Sir Robert S. *In Starry Realms*. 371 pages. Sir Isaac Pitman & Sons, Ltd., Bath and New York. Discusses various questions of popular interest regarding the sun, moon, stars, and other heavenly bodies.
- Chambers, G. F. *The Story of the Stars*. 160 pages. D. Appleton & Co., New York. Treats only of stars and constellations.
- Dolmage, Cecil G. *Astronomy of Today*. 363 pages, 45 illustrations, and diagrams. Seeling & Co., Ltd., London. Treats of celestial motions and distances, eclipses, solar systems, and stars.
- Macpherson, Hector, Jr. *Romance of Modern Astronomy*. 333 pages, 24 full-page illustrations. Seeley, Service & Co., Ltd., London. Treats in an interesting style of various astronomical topics.
- Newcomb, Simon. *Astronomy for Everybody*. 330 pages. Doubleday, Page & Co., Garden City, New York. Contains good illustrations of the planets, descriptions of astronomical instruments, and much about the solar system.
- Olcott, William Tyler. *A Field Book of the Stars*. 163 pages. G. P. Putnam's Sons, New York. Outlines and describes the constellations visible each season; gives the meaning of star names.
- Serviss, Garrett P. *Astronomy with the Naked Eye*. 247 pages. Harper & Brothers, New York. Devoted mostly to the stars and constellations; gives descriptions and charts.
- Todd, David P. *A New Astronomy for Beginners*. American Book Company, New York.
- Young, C. A. *Lessons in Astronomy*. 420 pages. Ginn & Co., Boston. Of the books covering the whole field of astronomy this is one of the most reliable and useful for the teacher or high school student.

PART THREE — BIRDS

Do you ne'er think what wondrous beings these?

Do you ne'er think who made them, and who taught

The dialect they speak, where melodies

Alone are the interpreters of thought?

Whose household words are songs in many keys,

Sweeter than instrument of man e'er caught!

Whose habitations in the tree-tops even

Are halfway houses on the road to heaven!

.

Think of your woods and orchards without birds! . . .

They are the winged wardens of your farms,

Who from the cornfields drive the insidious foe,

And from your harvests keep a hundred harms.

LONGFELLOW, *The Birds of Killingworth*



American Museum of Natural History

FIG. 157. Summer bird life on Cobb's Island, Virginia.

CHAPTER ONE

BIRDS



Finley & Bohlman

FIG. 158. Birds are the natural enemies of insects.

BIRDS and insects come to our notice oftener than most other creatures. Their rapid movements and bright colors or the sounds they make attract our attention. Some of our common insects spread diseases among us, and many of them destroy our crops; in the United States they take each year one tenth of all the farmer's produce and cause a loss of more than a billion dollars. Birds are the natural enemies of the insect world, — the balance nature has provided to hold insects in check. Almost all birds feed their young on bugs, flies, and worms, and many birds throughout their whole lives eat little other food. Indeed, if it were not for the work of the birds, insects would overrun the earth; in the stomach of one martin nearly 2000 mosquitoes were found. Whether birds are harmful or beneficial you

*Finley & Bohlman*

FIG. 159. Small birds rear their young almost entirely on insect food. The illustration shows a black-throated gray warbler feeding its young.

can judge after you have watched the feeding habits of a score or more of different kinds.

Birds may be studied both in town and country; in some city parks more than a hundred kinds have been seen. Wherever you find a variety of trees and shrubs you are likely to find a number of birds, if they are safe from enemies there. Look for them in orchards, pastures, and along the borders of ponds and brooks. You will find them at all seasons, but the best time to see them is when the leaves are developing on the trees.

To get a good view of a bird, take such a position that you can watch it without having to face the sun. If it is easily frightened, do not go straight toward it, but walk steadily as if you were going past. When looking for birds in the woods, walk quietly, notice

the motion of twigs or leaves, and listen to the various sounds. A windy day is unfavorable for bird study.

In a good locality for birds you may succeed in observing them if you sit down and allow the birds to come to you. If you have opera or field glasses, practice using them so as to bring a bird quickly into clear view. Try mimicking some of the birds you hear; you may succeed in calling them to you.

When you see an unfamiliar bird, make notes that will help you to identify it in a museum or by the use of a bird book. Compare its size with that of some common bird. Notice whether its bill is slender and straight, whether its wings and tail are short, any color markings you are able to see, and how it is getting food. Do not stop to make notes until you have watched the bird for some minutes or have lost track of it.



FIG. 160. A call for insect food.'

Finley & Bohman

A notebook will be useful also in keeping a list of the birds you see and various things you notice about their habits. Record the date, weather, locality where found, and any observations that interest you. If the notes you make outside are written up more carefully after you return home and before you go on another trip, they will be interesting and useful to you at various times, perhaps for years to come.

The birds described in the following pages are those that are most likely to be seen in the eastern and middle parts of the United States and Canada. However, not many of them may be seen at all seasons, and it is better to study each kind when it can be observed than to follow invariably the order in the book, where they are arranged according to their relationships to one another. It is not important to study every bird that is mentioned in the book. If you answer half the questions by means of your own observation, you will have acquired some real knowledge of birds.

References

The teacher should write to the National Association of Audubon Societies, 1974 Broadway, New York City, for information about the work of the Association and the literature prepared by it. For two cents each, leaflets giving colored pictures and full descriptions of all our common birds can be secured from the secretary, and assistance is also given in the organization of classes of school children for bird study. Several valuable bulletins on birds may be obtained by writing to the Secretary of Agriculture, Washington, D. C. Some of the states have published excellent books on the birds found within the borders of the state, and in large public libraries a great variety of bird books can be found.

CHAPTER TWO

THE THRUSH FAMILY



American Museum of Natural History

FIG. 161. A group of thrushes. From left to right: bluebird, veery, and wood thrush.

THE thrush family is found in all parts of the world and contains several hundred species. No other family of birds surpasses it in the musical ability of its members. Among European birds the song thrush, the blackbird, the robin redbreast, and the nightingale, all famous as singers, are thrushes. In America the family is represented by the robin, the bluebird, and the true thrushes.

THE BLUEBIRD

The Indians were delighted by the return of the bluebird from the South. To them it meant that spring was near and their long suffering from cold and hunger would soon end. Calendars afford us a more certain means of telling when to expect mild weather, but, nevertheless, the first joyous carol from the throat of a bluebird winging its way northward is a pleasant reminder that the time is near when life will be renewed upon the earth.



Joseph H. Dodson

FIG. 162. A house for bluebirds. The occupants are less likely to be molested by sparrows if the house is suspended by a wire than if it is fixed on a post or building.

Appearance of the bluebird. Bluebirds are so bright and beautiful and yet so common that it would seem as if every one must know them. Seen when strong sunlight illuminates the back, a male bluebird is indeed a conspicuous object. Thoreau says that it carries the color of the earth on its breast and of the sky on its back. When the bird is perching on a telephone wire or flying over us, we do not see the back.

Persons who do not observe the form of birds, or give heed to their songs and manner of flight, but merely notice their color, often see bluebirds without knowing what they are.

A bluebird is about $6\frac{1}{2}$ inches long, measured from the tip of its beak to the end of its tail. It is only slightly longer than an English sparrow. How do the wings of these birds compare in length? Are their beaks shaped alike? Do the sparrows ever drive bluebirds away?

Nests and young. As a site for their nests, bluebirds may use a hollow in an old apple tree. In what other situations have you seen nests? Houses intended for

them should be between 8 and 12 feet from the ground. A house without a perch is just as attractive to bluebirds as a house with one, and it is less attractive to English sparrows.

Bluebirds rear two and frequently three broods in a year. How many young are there in each brood? Some observers say that the young of the first brood assist in feeding later broods. Have you seen them assisting their parents? How can you distinguish the full-grown young bluebirds from their parents?

Usefulness of bluebirds. Bluebirds are prized not only for their beauty and their cheerfulness, but also because they do much good by devouring injurious insects. About two thirds of their food consists of grasshoppers, cutworms, bugs, and other insects. Of fruit they take little from cultivated vines and trees, but they eat elderberries, pokeberries, the fruit of the red cedar, dogwood, sumac, and poison ivy, and the seeds of various weeds.

THE ROBIN

The robin is about 10 inches in length. In many states it is our most common native bird; therefore people who know any birds besides chickens and sparrows are likely to know robins. The male and female are colored nearly



Finley & Bohlman

FIG. 163. A robin with a mouthful of worms for its young.

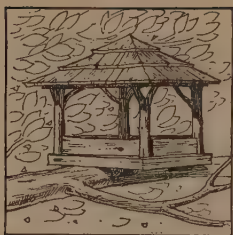


FIG. 164. Robins place their nests on branches of trees. They will occupy open houses that are placed in trees so that they are sheltered by the foliage.

alike. Do you know whether both male and female robins sing? Does either one sing before nest building begins? Where do they build? What materials do they use in making their nests? Is the same nest used more than one year? Is more than one brood reared in a season? Do the parents take turns in sitting on the eggs? Do they both feed the young? How long do young robins require parental care?

With what do the parents feed them?

Winter home of the robin. Robins usually spend the cold months in the South, but in thickets and in cedar swamps they winter as far north as Michigan. Give two reasons for their remaining in cedar swamps during the cold months. Have you ever seen a robin between the last of November and the middle of February? When do the first ones arrive from the South? When do they become common? How early do they begin building their nests? Are they as numerous as formerly? What is the largest number that you ever counted from one point of observation? Have you any reason to think that robins return in spring to the place where they were hatched?

At Sandusky, Ohio, an aluminum band was carefully placed on the leg of a robin that had not been long out of the nest. The following February this robin was found at Nashville, Tennessee.

THRUSHES

Thrushes are much like the robin in their habits, but their backs are olive-brown or tawny and their breasts white, with numerous small dark spots. They are smaller than the robin and larger than the bluebird. In yards that have considerable shrubbery, in parks, and in woods, thrushes are likely to be common in April and May, sometimes even more numerous than robins. Like the latter, they get much of their food from the ground. When migrating they are usually quiet, but after they reach their summer homes the woods resound with their melodious voices. During the migrating season five kinds of thrushes may be seen, but in summer some of these are to be found only in Canada and the northern part of the United States. It is easy to know a thrush, but not easy to distinguish the different kinds.

The wood thrush. This is the largest of the thrushes. It has the under parts most conspicuously spotted. The top of its head and neck are a brighter cinnamon-brown than the back. It breeds throughout most of the eastern half of the United States, and is one of the two thrushes likely to be seen in summer farther south than the Great Lakes. The brown thrasher, often called brown thrush, does not belong to the thrush family (page 295).

The hermit thrush. The hermit thrush differs from other thrushes in having the tail a brighter brown than the back. Many of them winter in the Southern states; some in Cuba and Mexico. In the Northern states they may be seen for several weeks in April. Some nest in Minnesota, northern Michigan, and New England.

John Burroughs calls the song of the hermit thrush the finest sound in nature. It seems to be the expression of a deep peace and a solemn joy such as only the finest souls may know. Have you ever heard one sing? How early does it arrive at your home? Why is it called "hermit" thrush?

Wilson's thrush, or veery. The back of this thrush is a uniform cinnamon-brown. Its sides are whiter and its breast less noticeably spotted than those of other thrushes. Many veeries spend the summer as far south as the North Carolina mountains.

The olive-backed thrush. The olive-backed thrush has a cream-buff eye ring and a strong tinge of this color on the throat and breast. The upper parts are a uniform olive-brown, the under parts light, with black spots. It is likely to be seen in great numbers for three or four weeks in May, when migrating North. In the latter half of May it may be heard singing in the shade trees before it departs for its summer home.

The gray-cheeked thrush. The gray-cheeked thrush resembles the olive-backed thrush so closely that few persons can tell them apart. The most noticeable difference between them is that the gray-cheeked thrush has a whitish instead of a buff eye ring and less buff color on the throat and breast. It migrates at the same season as the olive-backed thrush. Both are similar to the *russet-backed thrush*, which is abundant in the Pacific coast region.

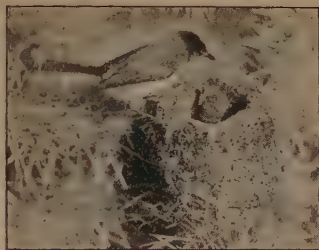
CHAPTER THREE

KINGLETS

WITH the exception of the hummingbirds, kinglets are our smallest birds. They are olive-greenish above, and whitish beneath, without streaks or spots. Like some other very small birds they are not likely to be frightened by your presence; when you are watching a kinglet at close range, it is almost as likely to move toward you as away from you. Why should very small birds show less fear of man than larger ones?

Two species of kinglets. There are only two kinds of kinglets in the United States, the *golden-crowned* and the *ruby-crowned*. They may be distinguished by the color of the feathers on the head. In the one species the crown is orange, bordered by yellow and black, in the male, and yellow, bordered by black, in the female. The male of the other species has a patch of red, more or less concealed when the bird is not excited, on the crown. No crown patch is found on the female of this species. The golden-crowned kinglet has black stripes on the head; the other species lacks these stripes. The length of a kinglet is about $4\frac{1}{2}$ inches.

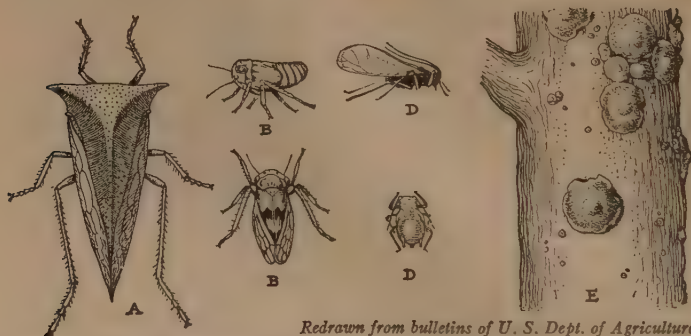
Other facts about the kinglet. Kinglets are common for some time in the spring and fall. Does either species



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FIG. 165. Plumbeous gnatcatcher at its nest in a cactus. This small Western bird is a relative of the kinglet.

remain near your home all winter? If so, which species? Some spring you may have the good fortune to hear the



Redrawn from bulletins of U. S. Dept. of Agriculture

FIG. 166. Some insects that are destroyed by the kinglet: A, tree hopper; BB, young and adult leaf hoppers; D, winged and wingless forms of plant lice; E, scale insects. All three times their natural size.

beautiful song of the ruby-crowned kinglet, and you will be surprised to find that so loud a sound comes from so tiny a bird. How can such small birds keep warm? Why are they called kinglets? The golden-crowned kinglet, like many other Northern birds, is attracted to evergreens, although often seen in other trees and in bushes.

Kinglets eat bugs, beetles, wasps, flies, and insect eggs and the berries of elder and poison ivy. The insects they eat include some of the most harmful kinds, — plant lice, scale insects, tree hoppers, and leaf hoppers.

CHAPTER FOUR

CLASSIFICATION OF BIRDS

ROBINS, bluebirds, and thrushes belong to the same family of birds. This family does not include any of our other birds. The others belong to other families, of which there are many, some including many species, some only a few. The birds of one species are all nearly alike, except for differences due to age, season, sex, or some unusual peculiarity. The bluebirds of the eastern part of North America are all of the same species. In the Rocky Mountains are bluebirds of other species. The birds of a blue color in the eastern part of North America are not all of one species. The blue jay and the indigo bunting, for instance, are conspicuous for their blue color, but they are not bluebirds and do not even belong to the same family as the bluebirds. To classify birds by color alone would be like classifying people by the clothes they wear. It might not always be wholly useless, but it would not group the birds in a natural way.

Birds classified according to natural relationships. Naturalists put in the same family those species of birds which are closely related to each other. The members of the thrush family, including the bluebird and robin, are believed to be actually related, in the same sense that you and other descendants of your great-grandparents are related. Of course the relationship of these birds is not so close as that. It may be better compared to your relationship with every person of your own race. If you had a complete genealogy going back many thousands of years, you would find that all the persons of a race

had common ancestors. In like manner naturalists believe that the members of the thrush family are all re-



FIG. 167. A, foot of a perching bird; B, foot of a wading bird; C, foot of a swimming bird; D, foot of a bird of prey.

lated and that if we could trace their ancestry far enough back we should find that robins, bluebirds, and thrushes had a common ancestor; that is, if we had lived at some period in the history of the world, perhaps many thousands of years ago, we would not have seen robins, bluebirds, and thrushes, but some one bird from which they have all sprung.

It is true also that robins and birds we classify in other families, such as sparrows and crows, had common ancestors, but their relationships are not so close. In other words, the common ancestors of crows, sparrows, and robins did not live so recently as the common ancestors of thrushes, bluebirds, and robins, but it is believed that all birds have descended from one kind of bird, the remains of which have been found in rocks formed millions of years ago.

Guides in classifying. In classifying birds, naturalists are guided by the structure of the different parts. This includes such characters as the general form of the bird, the shape and length of the beak, the arrangement of the toes on the foot, or the thickness of the walls of the gizzard. They are guided also by a study of the young



FIG. 168. Because the breast of the young robin is speckled, it is believed that the robin is descended from an ancestor that had a spotted breast.

birds, because young plants and animals are believed to come through, in their development, the same changes that the race has undergone (page 114). Young robins and bluebirds have spotted breasts, as the thrushes have throughout life. For this reason it is believed that the ancestor of the thrush family had a spotted breast. A careful study of the development of the young before hatching is therefore made in order to determine the relationships of birds.

Scheme of classification. If a naturalist wished to classify a ruby-crowned kinglet, he would at once place it in the animal kingdom. He would also know that it

belongs in the *vertebrate* subkingdom which is the group of backboned animals, and in the class *Aves*, or birds. Because the feet of the kinglet are fitted for perching he would place it in the order *Passeres*, or perching birds. Because of the shape of its beak and of other characters he would decide that it belongs in the *Sylviidæ*, or family of Old World warblers, and in the genus *Regulus*. Then, because of the red feathers on its crown he would assign his kinglet to the species *Regulus calendula*, the ruby-crowned kinglet. His complete scheme of classification, then, is as follows :

Kingdom	Animal
Subkingdom	Vertebrate
Class	Aves, or birds
Order	Passeres, or perching birds
Family	Sylviidæ, or Old World warblers
Genus	Regulus, or kinglet
Species	Regulus calendula, or ruby-crowned kinglet

The name of the species tells exactly which kind of bird it is ; the species *calendula* includes only the ruby-crowned kinglets, not the golden-crowned or other kinglets.

The genus is a larger group consisting of closely related species. All different kinds of kinglets belong to the genus *Regulus*.

The family is a still larger group consisting of related genera ; the family *Sylviidæ* includes not only the kinglets but many of their relatives in the Old World.



Finley & Bohlman

FIG. 169. Young of the cactus wren. The form but not the color of this bird shows that it belongs to the wren family.

The term "order" denotes a group larger than a family. All the families of song birds belong to one order, the *Passeres*, or perching birds. The various kinds of ducks, geese, and swans belong to another order, the *Anseres*, or swimming birds.

Finally, all birds belong to one class, *Aves*, which with the other classes of backboned animals (mammals, reptiles, amphibia, and fishes) constitute the great vertebrate branch or subkingdom of the animal kingdom.

The careful student will make an effort to distinguish between species, genus, family, order, class, and subkingdom. These terms are used not only in the classification of birds, but also throughout the animal and plant kingdoms. The trees as well as the birds are divided into families, genera, and species.

CHAPTER FIVE

TITMICE AND NUTHATCHES



Finley & Bohlman

FIG. 170. The chickadee has a larger family than most birds. Like the nuthatches, it nests in holes.

THE titmice and nuthatches of this country are small, plain-colored birds. They subsist principally on insects, which they find by searching over the foliage and bark of trees. They do not go in large flocks, but after the nesting season small companies of titmice, associated with nuthatches and oftentimes with one or two other kinds of birds, are likely to be encountered in the woods. Titmice and nuthatches belong to two different but closely related families. The titmice have short bills; the nuthatches, long bills.

The chickadee. The black-capped chickadee, or titmouse, is a favorite with many bird lovers. It is amusing as an acrobat, wonderfully confiding, and seems to be cheerful at all seasons. In many woods and city parks it is quite common both in summer and winter, although in some large districts it is seldom seen. It is smaller than an English sparrow, its back is of a bluish gray or

ashy color, and the chin, throat, and top of its head are black. Its length is about $5\frac{1}{4}$ inches.

Chickadees feed mainly on insects and insect eggs gleaned from the boughs and foliage of trees. They devour large numbers of cankerworms. In their search for food they often hang, back downward, underneath a swaying branch.

They lay from five to nine eggs, and nest in hollow stumps, or in trees at no great distance above the ground. Sometimes they use nesting boxes that have been provided for them. The entrance hole in a chickadee house should be near the top.

Both male and female chickadee utter the note *phæbe*. By whistling this you may succeed in calling one of them close to you, and possibly have the pleasant experience of getting one to light upon you, as a number of bird students have done. Another of their notes is *chick-a-dee-dee-dee*. They become very tame where they are fed in winter, both in the woods and in town. They take suet hung in a tree for them, and may be induced to enter an open window to get the crumbs of a doughnut. Some persons have succeeded in getting chickadees to eat sunflower seeds from the hand or even to take food held between the teeth.



H. B. Logan

FIG. 171. The chickadee is a favorite with bird lovers because of its confiding disposition.



Finley & Bohman

FIG. 172. Verdin feeding its young. This bird is a Western relative of the chickadee, and like the chickadee has little fear of man.

The tufted titmouse. The tufted titmouse is a more southern bird than the black-capped titmouse. But its range extends north to the Great Lakes, and like some other species of birds it may be found as far north in winter as in summer. It often appears in towns, but is more common in the woods. Its prominent crest makes it easy to distinguish from other small gray birds, and it often attracts attention by its loud, clear whistle, *peto, peto*.

Nuthatches. These small, bluish birds remind one of the woodpeckers, for they run up the trunks and large limbs of trees in search of food. They do not sing, but twitter, as they work; occasionally they utter a loud nasal *yank, yank*. Unlike the woodpeckers, nuthatches at times move head first down the tree. Their beaks are not such good drills as those of woodpeckers, and so they do not bore as deep into hard wood.

Nuthatches nest in holes in trees or stumps. They lay rather more eggs than do the larger song birds. Some nest in hollow limbs provided for them in open woods, orchards, or quiet gardens. These nesting places should be located 15 feet or more above the ground.



Harriet S. Rider

FIG. 173. White-breasted nuthatch enjoying a winter meal.

Nuthatches eat grubs and other insect larvæ that injure trees. On one occasion the writer saw a nuthatch carry an acorn. After inserting it behind a loose piece of bark, it picked the acorn open and apparently ate it. As soon as the bird had flown away, the acorn was examined. Some of it had been eaten, but not recently; something besides the bird had been feeding on the acorn. Can you explain this?

The *white-breasted* and *red-breasted nuthatches* are the two species most common in the northern and eastern parts of the United States. The white-breasted nuthatch is 6 inches in length; the red-breasted is somewhat smaller. The latter is a rather rare bird. Its breast is not red, but merely reddish brown in the male and pale brown in the female. It nests in Canada and the northernmost part of the United States.

How do you suppose nuthatches got their name? At what time of the year do you see them? Are their tails stiff like the tails of woodpeckers?

CHAPTER SIX

FEEDING BIRDS IN WINTER



Finley & Bohlman

FIG. 174. Varied thrushes, or Alaska robins, feeding on apples in the snow. Many of these birds spend the summer in Alaska and the winter on the western coast of the United States.

OF late years thousands of persons who formerly took little notice of birds have become interested in them and have learned that with a few exceptions birds are useful. In fact, without the assistance of birds it might be difficult to prevent insects from multiplying to such an extent as to destroy all kinds of crops. One year the pear-tree *Psylla* entirely destroyed the crop of a large pear orchard near Rochester, New York, and the owner thought there were no prospects for a crop the following year; but "nuthatches came and worked in flocks in his orchard all winter, and in the spring he could find scarcely an insect. Thus these nuthatches saved him thousands of dollars in one winter."

Because of their great usefulness in keeping insects in check, many persons now try to attract birds to their farms and orchards. Other persons who give little thought to the usefulness of their feathered friends pro-

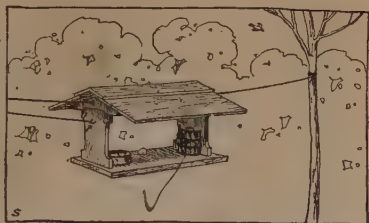
vide homes for them and feed them because they enjoy watching them and listening to their songs.

Feeding places for birds. In order to keep birds around, it is well to provide shelves and shelters where they may procure food in winter.

These may be placed in the woods, in a yard, or on the top or side of a building. Various birds will take food from a shelf just outside a window. During a snow-storm they will take refuge under a shed that is open on one side, preferably toward the south. Such a place makes a good feeding ground when the earth is covered with snow. If the birds are in danger from cats, the front of the shed should be covered with poultry netting with a 2-inch mesh. This will permit the birds to enter the shed through the meshes and at the same time will protect them.

Food for birds. Naturally many of our winter birds feed on seeds. For cardinals, juncos, snowflakes, and others of the sparrow family, wheat, millet, hemp, sunflower, and various other kinds of seeds are suitable. Crumbs and nut meats are relished by these and other species. Chaff from a haymow may be scattered on the snow.

Nuthatches, titmice, woodpeckers, and several other useful birds are attracted in winter by animal food.



From photograph by Joseph H. Dodson

FIG. 175. A feeding shelf for birds. The shelf is drawn to the window by a cord and the food placed in it; then by its own weight it slides down the line to the tree.

*Harriet S. Rider*

FIG. 176. A chickadee taking dinner in a Christmas tree.

Suet and bones split open to expose the marrow, or with meat clinging to them, may be hung in orchard trees that are infested with insects. The suet should be wound with string or inclosed in wire netting to prevent the whole from being carried off at one time. A "food stone" is attractive to birds and prevents waste. This is made by adding seeds to melted suet and letting the whole harden on a piece of board.

Feeding should begin in the fall, so that the birds may be induced to remain in the vicinity. In winter, when it is harder for them to find food, the feeding should not be neglected. Birds are not likely to freeze if they can keep dry and get enough to eat.

CHAPTER SEVEN

THE BROWN CREEPER AND THE WRENS

THE brown creepers and the wrens show a resemblance in size and color as well as in the shape of the bill and wings, but they differ enough to be placed in different families. Of the creeper family only one species, the brown creeper, is found throughout the United States and southern Canada. About 30 species of wrens live in the Old World and more than 200 species in America, 14 of them in the United States and Canada. They are small, plain-colored birds with short, rounded wings and slender bills adapted for eating insects.

The brown creeper. The name "brown creeper" is almost enough to enable you to recognize this bird. It is a very small bird ($5\frac{1}{2}$ inches in length), with long and pointed tail feathers. If you see such a bird alight on the trunk of a tree near the ground and creep up to where the trunk divides into branches and then, after a little, fly to the base of another tree trunk to repeat the operation, you may be sure it is a brown creeper. Does it creep straight up a trunk? If not, how should you describe its motion? Is there any advantage in its pointed tail feathers? If you are able to get a near view of the beak, you will see that it is curved, slender, and finely pointed. For what is such a beak adapted? Its claws are long, much curved, and sharp. For what are they adapted?

Have you seen brown creepers at all seasons? If not, when? Are they useful or harmful to the trees?

The house wren. The house wren is common in the woods and orchards as well as about buildings. It is

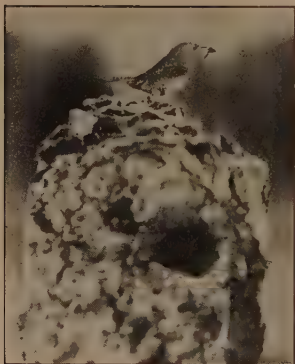
*Finley & Bohlman*

FIG. 177. A house wren on the roof of its home. This small bird is one of the most valuable orchard or garden tenants.

$4\frac{3}{4}$ inches long, and barely half as heavy as an English sparrow. It is reddish brown, and has a slender bill quite unlike the bill of a sparrow. It winters in the southern United States and in Mexico.

Wrens have a propensity for going into holes, not merely to nest but perhaps for protection or in search of food. They eat weevils and other beetles, crickets, grasshoppers, bugs, cutworms and other caterpillars, spiders, and ticks. Where brush piles are accessible, the wrens seem to be quite at home in them. Could they find food in such places?

Wrens are as interesting to watch as any of the birds that commonly make their homes close to the dwellings of men. They scold on the approach of a cat or of a strange person. When they are in a better mood, their lively, bubbling song seems loud enough for birds three times their size. The surplus energy of a wren is manifested in its quick movements and jerking tail, which it often holds up almost at a right angle with the back.

Wrens build more nests than they use; that is, they fill various cavities with materials like those used in making their nests. They lay from six to ten eggs. These are of a pale reddish color, with fine dots of a darker shade. A box for wrens should have the opening too

small to admit an English sparrow and far enough above the bottom to leave quite a space for the wrens to fill; for they build bulky nests of coarse materials. A 1-inch auger will bore a hole the right size for the entrance. A gourd or old tin can may be used, instead of a box. Wrens do not like the fresh appearance given by paint or recently dressed lumber. The box may be placed 8 to 12 feet from the ground, in a tree in the garden or orchard, or in an arbor. A pair of wrens once entered a chamber window that was left open, and made their nest in a slipper.

Name the nesting places you have known wrens to use. Of what materials do they make the nest? Do they raise more than one brood in a season? Do they return in spring to their old home? At what date do they appear in your locality? Do they become accustomed to the people they frequently see, and permit them to approach quite near? Do they ever fight with birds that would dispossess them of their nesting sites? Do they ever take possession of nests built by other birds? When a wren is singing, can you see any motion of its throat or of other parts?

The Carolina wren. The Carolina wren is larger than



U. S. Dept. of Agriculture

FIG. 178. Carolina wren.

the house wren, and its color is a brighter reddish brown. It has a white throat and a white line over the eye. In the Southern states it is



FIG. 179. The cotton-boll weevil. The members of the weevil family are characterized by the long proboscis, by which they can make their way into grains, peas, beans, and even nuts.

common, and it occasionally nests as far north as the lower Connecticut and Hudson River valleys and the vicinity of Lake Erie. In the

woods these birds attract attention by their nervous activity, loud and lively song, or variety of clear, ringing whistles, which remind the listener of the whistle of a tufted titmouse. They sing every month in the year.

The Carolina wren should be highly prized wherever cotton is raised, for it eats the boll weevil, besides insects that destroy various other crops. The *Florida wren*, which is found only in that state, is slightly larger and darker than the Carolina wren.

Other species of wrens. Over the western and southwestern section of the United States a number of other kinds of wrens are found ; several species of *marsh wrens* live in different parts of the country ; and in the Eastern and Central states there is a wren that winters as far north as Massachusetts and Illinois, while a different *winter wren* lives in the West. All these wrens are small, brownish birds, resembling in many ways the house wren that is so well known.

CHAPTER EIGHT

THE BROWN THRASHER AND ITS RELATIVES

THE birds of this family attract attention by the loudness and wonderful variety and richness of their music. In this and many other ways they resemble thrushes. They have shorter wings and longer tails than thrushes, and their bills are longer and more curved. The family is confined to America, and most of the species live in warm regions.

THE BROWN THRASHER

The brown thrasher is commonly called the brown thrush, but it is more nearly related to the wrens than to the true thrushes. It is colored somewhat like the house wren, but is much longer, being about 11 inches in length. The tail alone is 5 inches long, which is more than the length of the house wren from tip of beak to end of tail. The color of the thrasher is not olive-brown like that of the various true thrushes, but cinnamon-red. Underneath it is buffy white, with numerous dark brown streaks.

The song of the thrasher. The song of the brown thrasher may be heard at a distance of a quarter of a mile. It consists of a medley, whose parts may seem to come from different birds. After a rapid succession of notes comes a short pause, then another series of a different pitch. When planting corn, boys sometimes imagine that the brown thrasher says to them, *Dig-a-hole, dig-a-hole, put-him-in, put-him-in, stamp-him-down, stamp-him-down*. Like a soloist who entertains large audiences, the brown thrasher, when singing, occupies a conspicuous place, often high in a tree. At other times he is on the ground or in the shrubbery, thickets, or hedgerows.



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FIG. 180. Young crissal thrashers in nest. This thrasher lives on the sides of rocky cañons of the southwestern part of the United States. Its powerful song may be heard in the fall as well as in the spring.

Nest and food.

The nest of the brown thrasher is placed in a bush or on the ground and is made of coarse material. The eggs are thickly speckled with brown. Uttering loud cries, the birds sometimes fly at a person approaching too near their nest and even strike him with their beaks.

Thrashers eat weevils, rose beetles, May beetles, wireworms, caterpillars, grasshoppers, crickets, and thousand legs, besides wild berries and some cultivated fruit.

Do the thrashers come from the South in the spring or do you see them at all seasons? Are they easy to approach? At what time of day do they sing? Can you hear their song in any month when they are in the neighborhood? Do they mimic the songs of other birds? How did the thrasher get its name?

THE CATBIRD

The catbird is an inch shorter than the robin and more slender. Its color is slaty gray, the crown and tail are black. Catbirds are common in bushes and low trees

along streams, and in the shrubbery and fruit trees about many houses. The call that gives rise to their name does not show their full vocal power. Have you ever heard their rich song? It is not so loud as that of the brown thrasher, but is fully as melodious. Do they perch in prominent places when they sing?

The food of the catbird.

Catbirds are not so useful as brown thrashers in destroying harmful insects. Half of their food consists of fruit; they eat cultivated cherries, strawberries, raspberries, and blackberries in

large quantities. Nevertheless, in most parts of the country they probably do as much good as harm. They belong to the same family as the brown thrasher and mocking bird. What resemblances have they?

Of the catbird Olive Thorne Miller writes: "The catbird is generous and helpful to others of his kind in trouble of any sort, feeding and caring for deserted or orphaned young ones of any species, and always ready to aid distracted parents in the defense of their home and little ones. He is very playful, full of droll pranks and quaint performances."



Joseph H. Dodson

FIG. 181. Cat guard on tree. These are very useful for protecting the homes of birds that nest in trees and shrubbery close to houses.

THE MOCKING BIRD

*Am. Mus. Nat. Hist.*

FIG. 182. A bird bath.

The mocking bird is the most famous singer among American birds, rivaling, if not surpassing, the skylark of Europe. It sings at all times of the day and on moonlight nights, and its song is so loud that everybody in the Southern states is familiar with it. Its ability to mimic various kinds of birds differs greatly with individual mocking birds. Formerly thousands were trapped and sold for cage birds, but this is now unlawful.

Description of the mocking bird. The body of a mocking bird is about the same length as that of a robin, but its tail is longer than the robin's. The under parts are soiled white, the back is ashy, and the wings and tail are dusky, set off by white patches which are conspicuous when the bird flies. Mocking birds are found chiefly in our Southern states, but individuals are occasionally seen as far north as Michigan and Massachusetts, even in winter. They are more common on the plantations and in towns than in wild places.

Food of the mocking bird. Like the catbird, the mockingbird is fond of fruit. It eats various wild berries, such as those of the holly, pokeberry, and elder. Cultivated raspberries and blackberries and other cultivated fruit form only a small part of its food. Nearly half its food consists of insects, including grasshoppers, cucumber beetles, cotton-boll weevils, and cotton-leaf worms.

CHAPTER NINE

WOOD WARBLERS



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FIG. 183. A group of warblers. From left to right: black-throated green warbler, Nashville warbler, Maryland yellowthroat, and parula or blue yellow-backed warbler.

AMERICAN warblers are not remarkable for vocal power. They get their name from their resemblance to the warblers of the Old World, although they belong to a different family from these famous songsters. They are not so small as kinglets, but, with a few exceptions, are smaller than most of our other birds. Many of them show some yellow color; one of the most common kinds, the yellow warbler, is nearly all yellow. Other kinds are mainly olive-green above and white or pale below. Some are black and white. Orange, blue, and red are less common colors in this family of birds.

For the most part the warblers of America nest in Canada and winter in tropical America, being seen in the United States principally when migrating. However, in most places a few species of the warbler family may be seen through the summer. About fifty-five species of wood warblers are found in the United States. Some of them are beautiful birds.



FIG. 184. Black and white warbler.

Warblers that nest in the United States. The *yellow warbler*, *yellowthroat*, *redstart*, and *black-and-white warbler* are species that are rather common in the United States throughout the summer. Which of these do you see most frequently? The *ovenbird* and *water thrush* also belong to the warbler family and spend their summers with us. The yellow warbler builds a beautiful, compact nest of silver-colored plant fibers, leaves, grass, and caterpillar's silk, and lines the nest with hairs, feathers, and the downy material from fern stems.¹ The nest may be in an elder bush, in a stout weed, or in a tree near a house. Usually it is at no great distance from the water. Oftentimes the egg of a cowbird is found in the nest of this warbler.

Maryland yellowthroats build their bulky nests in grassy hummocks in swampy places. Redstarts live in the woods and are seldom seen on the ground except when

¹ See *Bird Homes* by A. R. Dugmore.

in search of food for their young. Their quick movements and sharply contrasted colors — black, white, and reddish orange — attract the attention. The pretty cup-shaped nest, made of vegetable fibers, dead grass, and strips of bark, is built in a crotch or on a branch against the tree trunk.

The ovenbird constructs a nest of roots and dead leaves on the ground in the woods, where the litter of dead leaves and the cover of young spring growth make it difficult to find. The nest is arched or domed like an old-fashioned oven, with a fairly large opening at the side. The ovenbird is called also the "teacher bird," because it seems to say, "Teacher, *Teacher*, TEACHER, TEACHER, TEACHER, TEACHER, TEACH." Ovenbirds walk about on the ground, and in the spring migration, when they may be seen in towns as well as in the woods, many are killed by cats and probably by English sparrows.



FIG. 185. Ovenbird. To the right is shown the nest, which is entered by an opening on the side.



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FIG. 186. From left to right: Canadian warbler, worm-eating warbler, Louisiana water-thrush, and yellow-breasted chat.

They might be taken for small thrushes, as their under parts are white, with numerous dark spots. The back is olive-green and the top of the head golden brown, bordered with black. Sometimes they are called "golden-crowned thrushes."

Water-thrushes belong to the same genus as the oven-birds. They may be seen along the edges of woodland brooks. They resemble thrushes, but they belong to the warbler and not to the thrush family.

Other warblers. The *Nashville warbler* is named after a city. The *Connecticut warbler*, *Kentucky warbler*, *Tennessee warbler*, and *Maryland yellowthroat* are named after states. Some warblers, like *Wilson's warbler*, are named after ornithologists; others after trees or shrubs they frequent, as the *magnolia warbler* and *myrtle warbler*. Some have names that partly describe the color; for example, *black-and-white warbler*, *black-poll warbler*, *bay-breasted warbler*, *chestnut-sided warbler*, and *black-throated blue warbler*. Most of the warblers here mentioned and some others may be seen by any one who looks for them diligently the last week of April and the first three weeks



FIG. 187. The redstart, one of the warblers that nests in the United States.

of May, in suitable places in the Middle or Eastern states. In central Ohio, after a warm night with a south wind, about the second week of May, nearly a dozen species of the warbler family may sometimes be observed in a single yard or within a short distance of it. Old oak, thorn-apple, willow, and other trees that harbor insects and their larvæ furnish food for these migrants.

The food of warblers. Warblers migrate at night and spend much of the day searching the foliage and boughs for insects or capturing them on the wing. They are nimble little birds, and many of the insects they eat are too small to be noticed by other birds. But small insects, if sufficiently numerous, may do as much damage as larger kinds. Professor Herbert Osborn has shown that one acre of pasture frequently contains a million leaf hoppers, which consume as much grass as a cow. By destroying these tiny insects as well as grasshoppers, the Maryland yellowthroats are useful in pastures. Yellow warblers eat measuring worms, tent caterpillars, bark beetles, and other injurious insects. All the birds of this interesting family are beneficial.

CHAPTER TEN

MIGRATION OF BIRDS

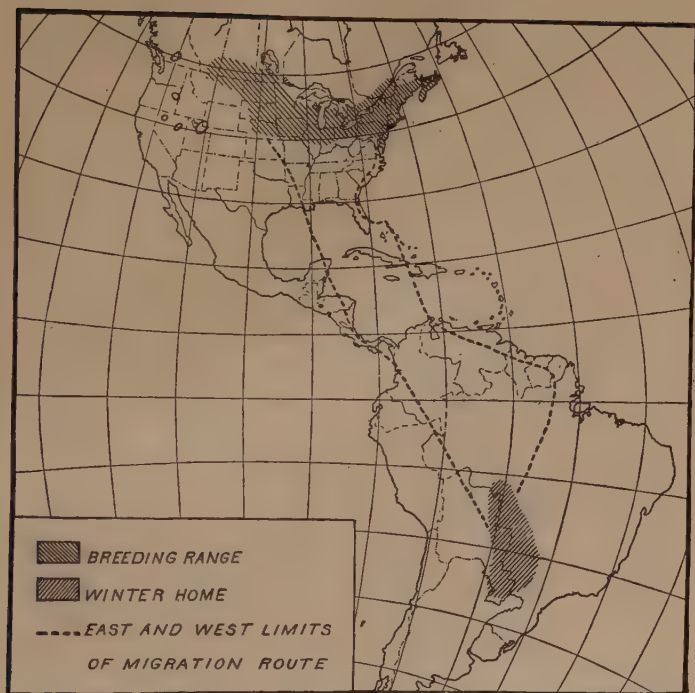
Swift overhead the small birds pass,
With cries that are lonely and sweet and clear.

CELIA THAXTER

FOR many years the Biological Survey of the United States Department of Agriculture has received reports from observers in different parts of the country, giving for each bird the date in spring when it was first noticed, when it became common, and when the last individuals were seen. These reports, supplemented by those of travelers and residents in other parts of the Western Hemisphere, have afforded much information about the movements of American birds.

Bird migrations. None of our common birds nest at the southern end of their migration range. They may go to Mexico or South America for the winter, but the North is where they rear their young. When the proper season comes, they have an impulse to start for their breeding places. Those birds which do not arrive at their Northern home until late in April or in May, when the weather is usually more settled than in March, may be expected at nearly the same time each year. Those kinds that arrive early in the spring sometimes make the mistake of coming North just before a severe storm or a spell of cold weather. Birds cannot foretell the weather any better than we can, but they are influenced by conditions that prevail where they are at a given time.

How birds find their way has long been a mystery. To some extent they follow river valleys or coast lines, but this fact does not fully explain the return of a bird, after

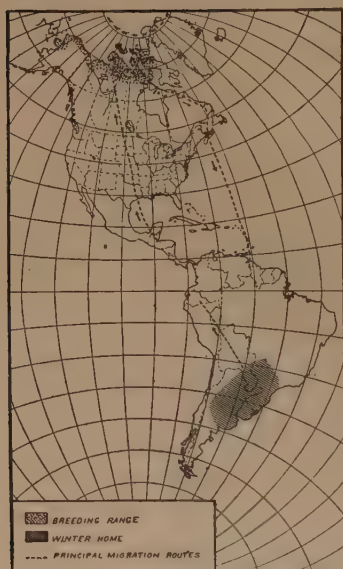


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FIG. 188. Map showing the summer and the winter home of the bobolink, and its migration route.

a journey of thousands of miles, to the very spot where it was hatched the year before. Birds and many mammals have a sense of direction which in man is not well developed, although some persons show something of it.

Rate of migration. The average rate at which a species makes its way northward across the United States is less than 25 miles a day, for the birds stop to get food and rest or to wait for better weather.



U. S. Dept. of Agriculture

FIG. 189. The summer and the winter home of the golden plover, and its migration routes. In the autumn it flies over the ocean from Nova Scotia to South America, 2400 miles, — the longest known flight of any bird. In the spring it returns northwest by way of the Mississippi Valley.

Ducks and geese, when migrating, fly between 40 and 50 miles an hour. Many kinds of birds fly at a height of half a mile or more above the earth, some probably more than 2 miles. On cloudy nights they fly closer to the earth.

Birds that migrate at night often become bewildered in bad weather by bright lights. At such times many perish by flying against lighthouses.

Many birds, including various warblers and even the tiny hummingbird, cross the Gulf of Mexico, which involves a long continuous flight. Formerly it was supposed that small birds must be exhausted by such a long flight, but

it was found that instead of descending at the first opportunity, many of the migrants continued their journey without pause over the low, swampy coastal plain until they reached the higher land farther north. The golden plovers on their way to South America fly from Nova Scotia to the Lesser Antilles, not stopping at the Bermudas if they have good weather.

Thus at a single stretch they travel about 2400 miles, remaining on the wing for probably 48 hours. The energy required for this prolonged flight is attained by consuming the fat stored in their bodies. They start fat and become lean during the journey. If a 1000-pound airplane could be propelled with as little waste of energy in proportion to its weight, 1 gallon of gasoline would suffice for a flight of 160 miles.

Classification according to migratory habits. With reference to the time a species remains in a given place, birds are divided into four classes: (1) permanent residents, (2) summer residents, (3) winter residents, (4) transient visitors. The last class includes those which occur only during migration.

If the birds that may be seen in the course of a year near your home were classified in this way, which of the four classes do you think would include the largest number of species and which the smallest number? About how many birds would be in all four classes? To which class do most of the warblers belong? You might make four lists of the birds that occur in your neighborhood, classifying them in this way.

Oh, happy life, to soar and sway
 Above the life by mortals led,
 Singing the merry months away,
 Master, not slave of daily bread,
 And when Autumn comes, to flee
 Wherever sunshine beckons thee!

LOWELL

CHAPTER ELEVEN

VIREOS, SHRIKES, AND WAXWINGS



Finley & Bohman

FIG. 190. Young Cassin's vireos and the basket nest in which they were hatched.

THE birds treated in this chapter belong to different families, all small families, which in certain ways resemble each other. In many ways the vireos resemble wood warblers and so are placed next to them in a systematic arrangement of birds.

Shrikes show some resemblance in form and habits, but not in color, to both vireos and swallows. Waxwings do not seem to be closely akin to any other birds, but the form of their beak, wings, and other organs shows that the waxwing family is related to both shrikes and swallows.

Vireos. Vireos are not quite as large as English sparrows. They were formerly sometimes called



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FIG. 191. Red-eyed vireo on the right, and blue-headed vireo on the left.

“greenlets,” because their color harmonizes with the foliage in which they spend their time. The under parts of the body are white, or nearly so, in most species, but the throat and breast of the *yellow-throated vireo* are bright yellow. The *red-eyed vireo* has over each eye a white line bordered with black. It is a trifle larger than the *warbling vireo*, and its back shows more green color. In most parts of the United States two or three other kinds of vireos may be seen either during the migration season or throughout the summer. They eat cankerworms, chinch bugs, and the eggs and larvæ of various other insects.

Few birds are heard in the woods as often as the red-eyed vireo, and few in town as often as the warbling vireo. Yet neither is known by many persons. The warbling vireos often nest in shade trees overhanging sidewalks. Their nests, like those of other vireos, are suspended from a forked branch.

*Finley & Bohlman*

FIG. 192. Western warbling vireo at its nest.

Shrikes. These birds are about as large as a catbird or mocking bird. They are white beneath and gray above, with the wings and tail mainly black, and a black patch on each side of the head. The white tips of part of the wing and tail feathers and white spots at the bases of the wings give the bird a spotted appearance when it flies. The bill is hooked and adapted to tearing the flesh of the mice and birds on which the shrike feeds in part. From their habits shrikes might be taken for hawks, but they are really song birds. It is believed that their vocal powers are useful to them in securing food, — that by imitating the call of a young bird in distress, a shrike brings small birds to the rescue and then seizes and kills them. Because of its slaughtering animals and hanging them on hooks the shrike is often called the “butcher bird.” What do you think is its object in hanging on thorns the creatures it kills?

The *northern shrike* is a rather common winter visitor in the United States. In city parks it is welcomed be-

cause it kills English sparrows. It sings fairly well. About the time that this shrike leaves for its summer home in Canada, a similar but smaller species, known as the *migrant shrike*, arrives from the South and spends the summer with us. Although not common, it is likely to be seen by any one who drives several miles along a country road, for it



FIG. 193. Young California shrike.

perches on a telephone wire or in some other conspicuous place, from which its keen eyes enable it to detect grasshoppers at a distance of 50 yards. These, with large beetles and other insects, make up about three fourths of its food. Since most of these insects are injurious and since the shrike also catches mice and English sparrows, it is considered useful to man. However, shrikes kill various kinds of small and useful birds, besides snakes, frogs, and lizards. The *loggerhead shrike* is very similar to the *migrant shrike*.

In general appearance shrikes resemble mocking birds, so that in the Southern states they are sometimes called "French mocking birds." The shrike has, however, a black stripe on the side of the head which the mocking bird lacks. The nest of the shrike is often built in thorn trees, which makes it difficult of access for persons who might wish to destroy it. Do you think shrikes should be destroyed?

The cedar waxwing. Although cedar waxwings are not common, you may run across a whole flock of them at any season of the year except when they are nesting. They nest later than most birds. In Highland Park, Rochester, New York, 250 cedar waxwings were counted at one time in the barberry bushes and surrounding trees. Flocks of these birds commonly contain between ten and thirty birds.

Waxwings are about the size of bluebirds. Their upper parts and breast are rich grayish brown, the belly is yellowish, and the tail has a yellow band at the end. They have conspicuous crests which they seem to use in expressing emotion.

The remarkable tips of some of the feathers of the wing, resembling sealing wax, may be seen when a person is close to a mature waxwing. No use is known for these waxlike tips. The name "cedar bird" relates to their habit of eating berries of the red cedar. They eat also cherries and a great variety of berries, wild and cultivated, besides cankerworms and other destructive insects.

Waxwings are usually tame and unsuspicious. Their lisping notes can be heard only a short distance and would not attract the attention of any one except a student of birds. When the birds can be plainly seen, they are much admired.

CHAPTER TWELVE

SWALLOWS



Finley & Bohlman

FIG. 194. Young rough-winged swallows.

SWALLOWS are easily recognized by their habit of circling over the meadows or over water for long periods of time. A bird may be watched while it flies several miles without getting far from its starting point. They feed on flying insects, including the house fly. Their wings are long and pointed; their feet are small, not being used for walking or running but for perching only. Some species of swallows have the tail forked; in other species the end of the tail is even, or merely notched. They often nest in colonies; that is, a number of pairs nest not far apart. After the young are able to fly, large numbers of swallows, young and old, may be seen perching close together on wires. "Where they are numerous enough, the fly scourge is not known."¹

¹ Lynds Jones.

*Finley & Bohlman*

FIG. 195. A barn swallow at its nest.

Less than ten species of swallows occur in the whole of the United States and British America, but several of these are so widely distributed that five or six species may be seen by almost any person within a few miles of his home, if not on a single farm.

The barn swallow. In the country the barn swallow is better known than other members of the family. It flies very swiftly and usually quite low, and whether it is perching or flying it may be known by its deeply forked tail. Its throat and chest are a dark bay color; its back is black, with a steel-blue gloss. It measures about 7 inches in length.

If barns are so constructed that swallows cannot always find an entrance, then openings should be made purposely for them. The nest is a sort of mud basket placed on

a rafter. It is easy to see if the barn is not dark, but it should not be molested.

The cliff swallow. The cliff swallow resembles the barn swallow but may be known by the pale yellowish red color of the feathers of the lower back or base of the tail. Its pocketlike mud nest is not placed inside the barn, but under the eaves, where a dozen or more may be counted on one side of a single barn. Some of them nest beneath cliffs. The mud homes of this swallow are favorite nesting places of the English sparrow, and where this sparrow has spread into the country districts and become numerous about buildings, the cliff swallow has disappeared.

Barn swallows and cliff swallows are more likely to build under the roof of a barn if mud is accessible at the time they need it. Do they return to their old nests?

The tree swallow. The tree swallow differs from other swallows in having the under parts entirely white. It is usually the first of the swallows to gather in flocks after the nesting season. In summer hundreds at once may sometimes be seen flying over the water. When migrating along the Atlantic coast they have been seen in large numbers feeding on the fruit of bayberry bushes. Have you ever seen swallows eating any kind of fruit or other vegetable food?

Tree swallows nest in holes in trees not far from some body of water or marsh, or in crevices of cliffs. Sometimes they occupy boxes or houses that have been made for them. These may be placed 8 to 15 feet above the ground in trees or arbors, on buildings or on special posts set around the borders of fields.



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FIG. 196. Bank swallows and their nesting holes.

The bank swallow and rough-winged swallow. These swallows are so much alike that it is difficult to distinguish them. Their plumage lacks the metallic luster that may be seen on the backs of other swallows. Both of them nest, as a rule, in holes they make in banks. The nests are 2 or 3 feet back from the entrance. The rough-winged swallow nests also in crevices in rocky cliffs and stone bridges.

↓ The purple martin. The purple martin belongs to the same family as the swallows. It is larger than the swallow, its wings being nearly 6 inches long. The upper parts are glossy bluish black. The under parts are the same color as the back in the adult male, but partly white in the female. Martins will nest in boxes put up for them on high posts or buildings. A bird house with several apartments is often occupied by several pairs of martins, for, like the swallows, they are more sociable than most birds. Because bugs that resemble bedbugs are found in their nests, some persons have supposed that they are likely to bring bedbugs to a house. This is a mistake. These bugs are not of a kind that annoy people or that will stay

where people live. The same is true of the bugs found in the nests of barn swallows.

Purple martins are more common in the Southern states than in the North and are welcome guests about country houses where barn swallows come, if at all, only in the season of migration. In Ohio about one hundred martins have been hatched and reared in one season in the martin houses placed over a single store. In Missouri a colony of sixteen pairs of martins were watched from four o'clock in the morning until eight at night, while feeding their young. The males visited their offspring 1454 times, the females 1823 times.

Does the date of their return in spring vary much from year to year? Can you tell a purple martin or any kind of swallow by its note? Do swallows and martins fly less swiftly than chimney swifts (which are erroneously called "chimney swallows")? Do you think that any of these birds catch many mosquitoes? Did you ever know of any of them doing any harm? Do people in Europe prize swallows and martins as much as we do?



Joseph H. Dodson

FIG. 197. An apartment house for martins. Unlike most birds, many pairs of martins will nest close together.

CHAPTER THIRTEEN

TANAGERS

IN South and Central America and the warmer parts of Mexico there are at least three times as many species of birds as in that part of America which lies farther north. Many of these birds are plain colored, but in the tropical parts of both hemispheres there are more bright-colored birds than in cooler regions. Europe has not so many handsome birds as the United States, — not any that are so brilliant as our bluebird, blue jay, Baltimore oriole, or scarlet tanager. About 350 species of tanagers live in South America, but none are ever found in the Old World. Many of them have plumage of strongly contrasted colors, black, red, yellow, or blue, — two or more of these colors in the same bird. In size and form they resemble members of the sparrow family. Our species are 7 and 8 inches long.

Tanagers in the United States. Tanagers do not winter north of the Mexican border, but in summer four species occur in the United States. The most common of these are the *summer tanager* and the *scarlet tanager*. The former breeds as far north as the Ohio River. The color of the male is rose red; that of the female orange olive-green above and yellowish orange below.

The scarlet tanager goes as far north in summer as southern Canada. The adult male is a brilliant scarlet, excepting the wings and tail, which are black. The female shows no red color but is mainly olive-green above and greenish yellow below. During the August molt the male loses his scarlet and black plumage and takes the color of the female.



FIG. 198. Female summer tanager on her nest.

These beautiful birds are not rare, although they are not often seen by those who do not look up into the foliage of trees. Open woods where oaks grow are frequently chosen by tanagers for their summer home. Here they destroy numerous insects. The song of the scarlet tanager suggests that of the robin.

Is there any advantage to the female tanager in not being colored red like her mate? Do you know of any kind of bird in which both sexes are bright red? When do tanagers arrive from the South? The scarlet tanagers, and many of the summer tanagers go to South America for the winter. How far is that from your home?

CHAPTER FOURTEEN

SPARROWS



American Museum of Natural History

FIG. 199. And every little bird upon a tree,
Ruffling his plumage bright, for ecstasy
Sang in the wild insanity of his glee.

PHOEBE CARY

THE sparrow family contains more than one thousand species. They occur in all parts of the world except Australia. In the vicinity of your home it would probably be possible to see thirty or more species of this family in the course of a year. A dozen or more of these are known as sparrows of different kinds. Others are called finches, buntings, grosbeaks, or other names. All of them have short, conical beaks adapted to crushing seeds. Many kinds are useful to the farmer because they eat so many weed seeds. In summer their diet includes insects, which they also feed to their young.

Many kinds of sparrows are streaked with brown, so

that they are difficult to distinguish by their color and markings. When they are quiet, it is hard to see them on the ground or where they are in bushes or among dry grass. The family includes also some bright-colored birds, and among these as well as among the plain-colored ones are several good singers.

The English sparrow or house sparrow. In recent years this bird has spread over much of the United States and has become common about buildings in the country as well as in towns. In some parts of the Southern states it is seen only in winter. It is about $6\frac{1}{4}$ inches in length. The male has the middle of the throat and breast black. What other part of his plumage differs from that of the female? Describe the nesting habits of these sparrows. About how many of them have you seen together? Are many of them killed by people? Mention several other ways in which they meet death. Are they becoming more common in your neighborhood? How are they adapted to live in towns? Do they fight with one another? Do they molest other kinds of birds? Have native birds become scarcer since the English sparrow came? If so, do you think it is due to the English sparrow or to other causes? What good can you say for English sparrows? Of what evil practices are they guilty? On the whole, do you think the importation of these birds was wise?

The song sparrow. A song sparrow is as long as an English sparrow, but more slender. It has a more reddish brown color and has streaks on both the upper and under parts. These birds are common in the shrubbery along streams and country roads over much of North

America. In many states they are to be seen throughout the year. Their hearty song is always welcome and seems especially cheerful on cold but sunny days in the latter part of winter. It sounds like *Peace, peace, peace be unto you my dear little children*. It is usually the first bird music of the year to be heard out of doors. What is the earliest date on which you have seen or heard a song sparrow?

¹ There is a bird I know so well,
 It seems as if he must have sung
 Beside my crib when I was young;
 Before I knew the way to spell
 The name of even the smallest bird,
 His gentle-joyful song I heard.
 Now see if you can tell, my dear,
 What bird it is that, every year,
 Sings, "*Sweet — sweet — sweet — very merry cheer.*"

He does not wear a Joseph's-coat
 Of many colors, smart and gay;
 His suit is Quaker brown and gray,
 With darker patches at his throat.
 And yet of all the well-dressed throng
 Not one can sing so brave a song.
 It makes the pride of looks appear
 A vain and foolish thing, to hear
 His "*Sweet — sweet — sweet — very merry cheer.*"

HENRY VAN DYKE

The vesper sparrow. The vesper sparrow resembles a song sparrow, but may be distinguished by its white outer tail feathers, which show when the bird is flying. It is very common, not in woods, but in fields, and may run in front of you as you walk along a path. Its dull dusty color harmonizes with its surroundings. It nests

¹ From *The Poems of Henry van Dyke*. Copyright, 1911, by Charles Scribner's Sons. Used by permission of the publishers.

*Finley & Bohlman*

FIG. 200. Desert or black-throated sparrow, a common bird in the Southwest.

on the ground, sometimes close to a road. As its name implies, it sings late in the afternoon, but may also be heard at other times and especially early in the morning. The song resembles that of the song sparrow, but is more plaintive, — *Pe-to-see-see-see-see*, then a warble.

It comes from childhood land,
Where summer days are long
And summer eves are bland, —
A lulling good-night song.

Upon a pasture stone,
Against the fading west,
A small bird sings alone,
Then dives and finds its nest.

The evening star has heard,
And flutters into sight;
O childhood's vespers-bird,
My heart calls back, Good Night.

EDITH M. THOMAS

The chipping sparrow. The chipping sparrow, or chippy, is also called "hair bird," because of its habit

of lining its nest with horse hairs. The chippy is smaller than the sparrows previously mentioned. In summer the top of its head is chestnut colored, a white line separating this from a black line through the eye. Its breast is without streaks. It is one of the most familiar of the sparrows, often making its home in a yard where there are bushes and trees, in either of which it may nest. Its eggs are blue or bluish green, with brown spots. In place of a varied song the chipping sparrow has a monotonous trill.

The field sparrow. The field sparrow resembles the chippy, but has the upper parts somewhat lighter colored and the beak reddish instead of black. It is common, not in open fields, as one might expect from the name, but in peach orchards and scrubby growth. The song resembles that of the vesper sparrow, but ends with a trill, — *Creo, creo, creo, cree, cree, cre, e-e-e-e-e*. The boys call it the "locomotive bird." Why?

The tree sparrow. The tree sparrow resembles a chippy, but is larger and has more conspicuous white wing bars. On its breast is a dark spot. In some of the Northern states this is the most common native bird in winter, but its summer is spent farther north. When with us they are in flocks, and like other Northern birds they are easy to approach. They feed on the seeds of weeds that project through the snow.

White-throated and white-crowned sparrows. The white-throated and the white-crowned sparrows are much alike. Both are large and have the crown white, bordered with black, but the white center is broader in the white-crowned sparrow. The male white-throated sparrow, or Peabody bird, has the white of the throat con-

trasting strongly with the surrounding plumage. Both of these sparrows are common in the Southern states in

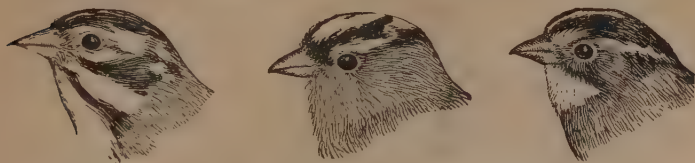


FIG. 201. Heads of lark sparrow, white-crowned sparrow, and white-throated sparrow.

winter and in the Northern states during the migration, when small flocks of them may be seen in thickets or hedgerows. Which of these sparrows do you find to be the more common in your locality?

Fox sparrow. The fox sparrow is the largest of our sparrows. The upper parts are rufous brown, the under parts streaked and spotted with the same color. It winters in all of the Southern states. Flocks of them may be seen for a long period in spring and fall when migrating through the Northern states. They frequent weedy grainfields, roadside shrubbery, and open woods, where they search for food by scratching among the fallen leaves. Fox sparrows are fine singers. They are often mistaken for thrushes.

Questions about sparrows. How many species of sparrows do you know? Which ones do you see at all seasons? Which ones in winter? Which ones in summer? Which ones only in the season of migration? How many of them can you recognize by their notes? Why do sparrows winter farther north than swallows? How do their wings compare with those of swallows? Explain the difference.

CHAPTER FIFTEEN

OTHER BIRDS OF THE SPARROW FAMILY



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FIG. 202. Female willow goldfinch.

THE birds described in this chapter belong to the sparrow family. Some of them—for example, the female indigo bunting or the goldfinches in winter plumage—may indeed be taken for sparrows; but the adult males are not streaked. In several of the species the males are brightly colored. All of them have stout beaks fitted for cracking seeds.

The junco. The junco belongs to the sparrow family. Its plumage is not streaked, but is grayish slate-colored on the breast as well as on the upper parts. The belly is white, and the sides of the tail show much white when the bird is in flight. Juncos are often called “snow birds” and in winter may be seen over much of the United States. How late in the spring do they remain in your locality? How many have you seen in a flock? What do they eat? Do you know the junco’s note?

The snow bunting. This snow bird or *snowflake* is

larger than the sparrow. It is mainly white, but shows a good deal of black on the upper parts. It rarely perches in trees, but walks on the ground or snow and subsists on seeds.

"Throughout Canada and the northern tier of states the snow bunting is the familiar little white bird of winter. As soon as the chill season comes on in icy



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FIG. 203. Young willow goldfinches in cherry tree.

rigors, the merry snowflakes appear in great flocks, and come foraging about the barnyards when there is no bare ground left in the adjacent fields. They get, apparently, but little to eat; but in reality they always find enough to keep them in health and spirits, and are as fat as butter balls. In mid-winter in the far North, when the thermometer showed thirty degrees below zero, and the chill blizzard was blowing on the plains, I have seen this brave little bird gleefully chasing his fellows, and pouring out, as he flew, his sweet, voluble song with as much spirit as ever skylark has in the sunniest days of June. As long as the snow lasts the snowflake stays, and as soon as the ground grows bare and there is promise of better days, this bird of winter betakes himself again to the north as far as the most northern habitation of man and there builds his nest."¹

The snow bunting lives also in Europe and Asia. Why are species that go far north likely to be found in both the Eastern and Western hemispheres?

¹ Ernest Thompson Seton, quoted in Chapman's *Birds of Eastern North America*.

The crossbills. These birds get their name from the fact that the tips of the upper and lower mandibles are crossed, making their beaks appear as if deformed. Such beaks enable them to pry apart the scales of cones and so are well adapted to removing the seeds from the cones of pines and other evergreens. They are not often seen except where such trees



FIG. 204. Crossbill.

abound. In the United States they are seen mostly in winter, but their migrations are not regular. Their nests, which are placed in evergreens, consist partly of moss.

Two species, the *American crossbill* and the *white-winged crossbill*, are found in Canada and in some parts of the Northern states, though the white-winged crossbill is not common in the States. In both species the males are partly red and the females brown with an olive or yellowish tinge. The red crossbill of Europe is similar to our species. Why is one species called American crossbill? What is the legend of the crossbill? See Longfellow's poem, "The Legend of the Crossbill."

The goldfinch. This bird is commonly called "wild canary." The name is not a good one, for canaries are wild, not in America, but in the Canary, Madeira, and some other islands in the Atlantic Ocean. The bright yellow color of the male goldfinch, together with his black crown, wings, and tail, makes him easy to recognize in summer. The female is of a duller hue. Some individuals remain in the North all winter, but at that season a flock of them will show but little yellow. They are among the smallest of the sparrow family.

Goldfinches eat various dry seeds, including those of the thistle. They are often seen near water, drinking or bathing. Their flight is wavering up and down, and as they fly, they utter the joyous notes which remind one of a canary. When do they breed? The *willow goldfinch* of the Pacific coast is a variety of the Eastern species.

The *European goldfinch* is one of the most handsome birds of that continent. It is often caged and has been set free in this country, but has not as yet become common anywhere.

The buntings. The beautiful *painted bunting* is not rare in the Southern Atlantic and Gulf states. The entire lower parts are vermilion-red, the back yellowish green, the rump dull purplish red, and the head and neck purplish smalt-blue.

The *indigo bunting* is nearly as small as the goldfinch. The males are a bright blue except for the wings and tail, which are blackish, the feathers margined with blue. The females are brown like the English sparrow, with a slight tinge of blue on the tail and wings of the adult. In a good light the mature males are beautiful birds, but their mates look so different that it is hard to believe they are of the same species.

Indigo buntings are common in summer in clearings. They may be seen also on telephone



U. S. Dept. of Agriculture

FIG. 205. Painted bunting.



Finley & Bohlsman

FIG. 206. Male lazuli bunting feeding its young.

wires along country roads. As with some other bright-colored birds, their color does not show unless they are viewed in the proper light. When their song is once learned, the birds will be noticed much more frequently than before.

The rose-breasted grosbeak. Several larger species of the sparrow family are called grosbeaks because of their large beaks. The *pine grosbeak* and *evening grosbeak* are Northern birds, and are seen occasionally in our Northern states in winter. The *rose-breasted grosbeak* spends the winter in the tropics and the summer in Canada and the northern parts of the United States. Its name would enable any one who has a good view of it to recognize the male bird. It is mainly black and white, with the breast rose-red. The female has no red color or conspicuous black and white markings, but is streaked with brown like sparrows of various kinds.

The male and female of this species take turns in incubating the eggs, the male frequently singing while

sitting on the eggs. The bottom of the nest is so thin that the eggs may be seen through it. The nests are commonly less than 12 feet above the ground, in second-growth timber or in orchards or parks.

The song of the grosbeak might be mistaken for that of a robin or scarlet tanager, but is superior to both.

"There is an exquisite purity in the joyous carol of the grosbeak; his song tells of all the gladness of a May morning; I have heard few happier strains of bird music. With those who are deaf to its message of good cheer, I can only sympathize, pitying the man whose heart does not leap with enthusiasm at the sight of rival males dashing through the woods like winged meteors, leaving in their wake a train of sparkling notes."¹

Grosbeaks are fond of the buds and blossoms of fruit trees; they eat also cherries, strawberries, and green peas.



Finley & Bohman

FIG. 207. Young black-headed grosbeaks.

¹ Frank M. Chapman, *Birds of Eastern North America*.

Do you think such a diet accounts for their beauty and musical ability? If so, how about their habit of eating Colorado potato beetles? The man who has no appreciation of music or color may, nevertheless, realize the value of a family of rose-breasted grosbeaks in the vicinity of a potato patch. They eat also various other injurious insects, the good they do in this way amounting to much more than the harm they do in fruit trees. Unfortunately, these fine birds have become rare in many places where they were formerly rather common. This is thought to be due to their having been poisoned with Paris green by eating potato beetles. The *black-headed grosbeak* is common in suitable woodland from the Plains to the Pacific. Its nest, eggs, and habits are like those of the rose-breasted grosbeak.

The cardinal. The cardinal is a kind of grosbeak and is easily distinguished from all other birds by its brilliant red color, large red beak, and prominent crest or topknot. It is larger than a scarlet tanager, and its wings and tail are not black. Tanagers are with us only in summer, but cardinals remain throughout the year, as far north as Lake Erie. The plumage of the male cardinal is mostly of a bright rosy red, but black about the bill; the female has the wings, tail, and crest dull red, the back olive-brownish. Both birds sing well, the song of the male being a loud, clear whistle, *Pretty, pretty, pretty*.

Cardinals occur as far north as central Michigan and are increasing in numbers. They are common throughout the Southern states, where they make themselves useful in the cotton fields by eating insects that feed on the

*Finley & Bohlman*

FIG. 208. Texas cardinal on her nest.

cotton plant. Formerly many were kept in cages. One died after being in captivity thirty years. How long it had lived before being caged was not known.

Where they are well treated, cardinals become familiar enough without being confined. In winter they will come every day and eat seeds from a shelf just outside a window. They may nest in a bush, a grapevine tangle, porch trellis, or even inside a conservatory.

The towhee. The towhee, chewink, or ground robin belongs to the sparrow family but looks more like a robin. It is smaller than a robin, but larger than our largest sparrows. The male has the breast and most of the upper parts black, the belly white, the sides colored like a robin's breast. The female has a grayish brown color in place of the black of the male. Both show considerable white on the tail when they fly. They are common throughout much of the United States at all seasons, a few remaining as far north as Lake Erie in winter. They live in woods where there is an undergrowth of shrubbery, feeding on

various kinds of wild fruits, seeds, and insects. They often scratch among the fallen leaves.

The names "towhee" and "chewink" are attempts to imitate the call of this bird, but the full song has several more syllables. The male, perched in the top of a low tree or tall bush, repeats his song many times.

Towhees usually nest under a bush or brush pile. Their eggs resemble those of cowbirds, being finely and evenly speckled with reddish brown, the color of the towhee's sides. Cowbirds often lay their eggs in the nest of the towhee.

CHAPTER SIXTEEN

THE BLACKBIRD FAMILY

THIS family of American birds includes about 150 species, most of which are not found so far north as the United States. Some of the members of the family differ much in color, vocal power, and habits from the blackbirds for which the family is named. They are related to the sparrow family but have as a rule a longer beak. Unlike most of our perching birds, they walk instead of hopping when they are on the ground.

Grackles. Our most common blackbirds are known as grackles or *crow blackbirds*, of which there are several kinds in the United States. When the lustrous plumage of the male is seen in a good light, the bird is handsome. How do they compare in size with robins? Are their tails as long as a robin's tail? How much of the year do they spend in your neighborhood? Do they show any preference for evergreens?

In many towns there are grackle roosts to which these blackbirds resort in great numbers year after year. After the young are able to leave their nests, hundreds of young and old come from miles around to roost every night in a few trees not far apart. Some trees have been used by the grackles for more than forty years. Do you know of such a roost?

Their nesting is done in smaller colonies, and they usually build a bulky nest at a considerable height in a spruce or other evergreen. Perhaps you have seen their nests in other situations. Have you ever seen them molesting the nests of other birds? Have you ever known them to make any music?



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FIG. 209. Male and female bobolink (on the left) and crow blackbird or purple grackle (on the right).

The food of grackles consists of some weed seeds and large numbers of destructive insects, such as the white grubs of the May beetle. They also eat many acorns, beechnuts, chestnuts, and some fruit, such as blackberries and cherries. Ordinarily these things in the quantities that the grackles consume might well be spared to compensate them for their assistance in killing insects, but they pull up young corn and eat such a large quantity of grain that some persons believe they should not be protected by law. Where the grackles are very numerous and troublesome, the farmer should not be blamed for protecting his crops in the ways he thinks best.

The red-winged blackbird. The male red-winged blackbird has on the shoulders a conspicuous patch of scarlet bordered with buffy white. When the bird is overhead, so that the bright color does not show, it

may be distinguished from the grackle by its shorter tail. The female is so different that it is hard to believe that she lays the eggs from which such handsome blackbirds develop. She is $1\frac{1}{3}$ inches shorter than the male, shows little or no red color and no solid black, her entire plum-



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FIG. 210. Young red-winged blackbirds.

age being streaked with black and light colors. In many of the states redwings are to be seen at all seasons. In the Northern states and in Canada they arrive very early in the spring, the males coming first. Unlike most song birds, they are polygamous. They make their homes in marshes, where their bulky nest is made of coarse grass and is supported by reeds, flags, or sometimes bushes, not far above the water.

More than half the food of the red-winged blackbirds consists of grass and weed seeds, such as foxtail, smartweed, dock, and sorrel. One fourth of their food is insects, mainly injurious kinds, such as weevils, cutworms, army worms, and grasshoppers. Before many of their breeding places had been drained, there were sometimes flocks of red-winged blackbirds numbering from 20,000 to 50,000. When such flocks visited grain-fields, the farmer lost much of his crop. But where these birds are not very numerous, they usually do more good than harm.

Brewer's blackbird. Brewer's blackbird is familiar to those who live in the western half of the United

States. It is smaller than the crow blackbird but larger than the redwing. The male is glossy greenish black, the head and neck purplish black. In the female the head, neck, and under parts are brownish gray. These blackbirds are common both about dwellings and in unsettled regions as low as the seashore and as high as the timber line on Mount Shasta. They nest in small colonies in sagebrush around the edges of marshes or in willows or oaks. They eat cutworms, cotton-boll worms, grasshoppers, weed seeds, grain, and fruit.

The cowbird. The cowbird is smaller than other kinds of blackbirds. The male is black except on the head and neck, which are coffee-brown. The female is grayish brown. Cowbirds are found throughout the greater part of North America. In many of the states they may be seen at all seasons. When buffaloes were common on the plains, these birds were called "buffalo birds," because they followed those animals about as they now follow cattle. What benefit do they derive from such an association?

Cowbirds build no nests and rear no young. The dull-colored female watches her chance to lay eggs in the nest of another bird when the owner is away. About 100 different kinds of small birds are imposed upon in this way by cowbirds. These birds, when unable to roll the intruder's eggs out of the nest, sometimes build a second floor over the eggs and make the walls higher. Nests have been found with three floors, cowbirds having laid eggs on both the first and second floors. As a rule the young cowbird is stronger from the first than the young of the bird that built the nest, so that it

*Finley & Bohlman*

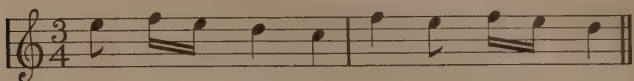
FIG. 211. Young western meadowlark.

gets more than its share of the food and, after a time, crowds the others out or causes their starvation. In this manner cowbirds are a serious hindrance to the increase of many kinds of useful birds, and so do not deserve protection. Their eggs are speckled and spotted with brown on a soiled white background, which often has a greenish tinge. The eggs are about $\frac{4}{5}$ of an inch long and $\frac{2}{3}$ of an inch broad.

The meadowlark. The meadowlark is a trifle longer than the robin. Its upper parts are brown, streaked and barred with black; the breast is yellow, with a broad, black, V-shaped collar. The white on the sides of the tail shows as the birds fly. Oftentimes, after taking a number of wing strokes, they will sail for quite a distance before alighting. In grassy fields throughout most of the United States they are very common in

summer, and in many states are to be seen also in winter. If they are not molested, some meadowlarks venture into parks and vacant lots in towns.

The song of the meadowlark is a clear, plaintive whistle of unusual sweetness, very different from a blackbird's note. It differs in different parts of the country and with individual birds in the same region. As usually heard at Englewood, New Jersey, Frank M. Chapman gives it:



Besides its song, a meadowlark has various call notes.

The nests of these birds are well concealed in the grass. Like a number of other birds that nest on the ground, a meadowlark will either remain on the nest until a person is almost on it or will try to lead him away from it.

Many meadowlarks have been shot by persons who wanted them for food or who merely wanted to shoot something. They are very useful birds, and ought to be carefully protected at all seasons. They eat grasshoppers, crickets, cotton-boll weevils, alfalfa weevils, wireworms, and caterpillars, including cutworms and army worms.

The bobolink. The bobolink¹ is known in the South as the "ricebird." The male in spring is entirely black beneath and partly black above, the rest being white and cream color. Sometimes it is called "skunk blackbird." Why? The female is pale buff, the upper parts and sides streaked with black. The beak is so short that the bobolink might be taken for a member of the sparrow family.

¹ Read Bryant's poem, "Robert of Lincoln."

A bobolink will sing while perched on the top of a tall weed or while flying. He seems to carry two parts in his song, so that you would think the music he makes must come from more than one bird. It is worth going to the fields to hear. May and June are the months to see and hear bobolinks at their best. In late summer both sexes are colored like the females in spring. They are then known as "reed-birds." They migrate in flocks by day and night, subsisting mainly on wild rice that grows in the marshes along the Atlantic coast. "Formerly, when the low marshy shores of the Carolinas and some of the more southern states were devoted to rice culture, the bobolinks made great havoc both upon the sprouting rice in spring and upon the ripening grain on their return migration in fall. With a change in the rice-raising districts, however, this damage is no longer done."

Bobolinks spend the winter south of the equator, but in summer are common in the meadows in Canada and in most of the Northern states. Why do they not arrive early at their Northern home? (See page 305.)

While in the North they eat a little grain, but they



William Hoot

FIG. 212. Male bobolink
on mullein stalk.

benefit the farmer by eating weed seeds and large numbers of noxious insects.

When nature had made all her birds,
With no more cares to think on,
She gave a rippling laugh, and out
There flew a Bobolinkon.

CHRISTOPHER PEARSE CRANCH

The Baltimore oriole. A number of beautiful birds arrive in the Middle and Northern states and southern Canada in the latter part of April or in May. The most common of these is the Baltimore oriole. It is larger than a sparrow, but considerably smaller than a robin. The under parts and the lower back of the male are reddish orange; the head, neck, and forward part of the back are black. The wings are orange, white, and black. The female is dull orange below, dusky and yellowish olive above. In winter these birds live in tropical America, where there are some forty species of orioles, but none that are more beautiful than the Baltimore oriole.

You have seen the purselike nest of the oriole hanging from one of the outer limbs of a tree. Does the male or female bird weave it? Is the female less exposed to view when in the nest than other birds when sitting? Is she as plain colored as the females of most birds? Did you ever see an oriole on the ground? Do any of the blackbird family get food from the ground? Does the oriole resemble a blackbird in shape?

The food of the Baltimore oriole consists mainly of injurious insects, including scale insects, plant lice, weevils, click beetles, May beetles, and numerous cater-

pillars. For some weeks after they arrive from the South the loud and joyous whistle of these birds resounds from orchard, garden, and city street.

How falls it, Oriole, thou hast come to fly
In tropic splendor through our northern sky?
At some glad moment was it nature's choice
To dower a scrap of sunset with a voice?

Or did some orange tulip, flaked with black,
In some forgotten garden, ages back,
Yearning toward Heaven till its wish was heard
Desire unspeakably to be a bird?

EDGAR FAWCETT

The bullock oriole. In the western part of the United States the bullock oriole takes the place of the Baltimore oriole. Although less handsome, it resembles the eastern species in appearance and habits. Its habit of eating the black olive scale and various caterpillars, including those of the codling moth, entitle it to protection by fruit growers.

The horned lark. The horned lark is not, like the meadowlark, a member of the blackbird family. It is a true lark related to the famous skylark of the Old World. Horned larks may often be seen feeding in roads like English sparrows. When they fly, they may be distinguished from sparrows by their longer wings.

CHAPTER SEVENTEEN

THE CROW FAMILY



Finley & Bohlsman

FIG. 213. A young magpie.

THIS family is found all over the world and includes about 200 species. Among them are the raven, rook, jackdaw, and various kinds of crows, most of them birds of somber plumage. Magpies and numerous kinds of bright-colored jays also belong in this family, and the beautiful birds of Paradise, found in New Guinea and other islands of the Papuan

region, are closely related to the crows and their allies. Of the birds of Paradise there are about forty kinds, differing greatly in size, color, and ornamental plumes.

In the various members of the crow family, the legs and feet are strong. They are adapted for walking on the ground or, in the case of the jays, which live more in trees, for hopping. The bill is straight and has sharp cutting edges. Its upper outline is curved. The nostrils are covered with tufts of bristly feathers. They eat almost everything which any birds eat. Being bold, cunning, and unscrupulous, many of them are disliked

by other birds as well as by man. Several kinds have been tamed and taught to imitate the human voice and pronounce a few words, but their mischievous disposition makes them at times annoying pets.

At the present time only two species of this interesting family, the crow and the jay, are widely distributed in the United States. Formerly ravens were found over much of North America, but they are now rarely seen south or east of the Great Lakes, though common enough in the Northwest. They resemble the common crow, but are larger, being 2 feet long and having a wing expanse of 4 feet.

The blue jay. The blue jay averages $11\frac{3}{4}$ inches long, or $1\frac{3}{4}$ inches longer than the robin. The difference in length is due mainly to the longer tail of the jay. The back and prominent crest are purplish blue; the wings and tail are bright blue, with small black bars. The tail is edged with white, and the wing has conspicuous white bars. The under parts are pale purplish gray or whitish, except for a black collar. At all seasons blue jays may be seen in the woods and towns in Canada and a large part of the United States. They are considered by many persons the most beautiful of our winter birds. If their ways were as fine as their plumage, they would be highly appreciated, but many of them have bad habits. They occasionally rob the nests of various other birds, eating the eggs and young or carrying them off to supply food to the hungry mouths in their own nests.

Jays eat a great variety of food, both vegetable and animal. They store acorns and other nuts in knotholes

or crevices or bury them in the ground for future use. Both wild and cultivated fruits of many kinds, weed seeds, and corn form a part of their diet. They do good by devouring scale insects, caterpillars, and grasshoppers.

Blue jays have a great variety of calls, some of them quite musical. They seem to mimic several other birds, especially some of the hawks. Although they are handsome, an increase in their numbers, such as has been noticed in many places, seems undesirable, because of their bad habits.

At what season do you see the greatest number of jays? What do they find to eat in winter? Did you ever try to tame a young blue jay? Why do some persons mistake jays for catbirds?

The California jay takes the place of the blue jay in the Pacific Coast states. Great quantities of cherries, apricots, and prunes, as well as the eggs and young of hens and small birds, are eaten by them.

The crow. The crow is entirely black and is about half a yard long, which means that it is much larger than any of the birds described in previous chapters. It is also more intelligent. So cunning is the crow that in spite of persecution it maintains itself in large numbers throughout the greater part of North America.

The crow makes a bulky nest of sticks, with a lining of finer materials, placing it in a tree at a height of 30 feet, more or less. Outside of the nesting season they congregate in great numbers at certain roosts, to which they may be seen flying in all directions about sunset. They leave the roost at daybreak, some of them going many miles in search of food.

A great variety of food is eaten by crows, but corn is the most important article in their diet. They prefer sprouting grain and corn in the milk to hard kernels. They eat various kinds of fruit, wild and cultivated. They eat the berries of the poison ivy, and this vine comes up in many places from seeds they have dropped. They eat many young chickens and both the eggs and the young of game birds and song birds. On the other hand, crows do good by devouring the grubs of the May beetle, tomato worms, grasshoppers, and other injurious insects. Much of their insect food consists of species that are not injurious or of insects which are dead when the crows find them.

Crows are not protected by law. In many places the farmers have good reasons for killing them. Contrary to a popular impression, their flesh is good to eat.

The language of crows would make an interesting study. Their usual call is *Caw*. If they think they are in danger, they cry, *Kawk-kawk-kawk*. When the danger is over, they say, *Caw-aw, caw-aw, caw-aw*. They make interesting and mischievous pets.

CHAPTER EIGHTEEN

THE STARLING



Am. Mus. Nat. Hist.

FIG. 214. The starling.

THE European starling resembles our native blackbirds in form, size, and color. The plumage is more purplish or greenish than that of a blackbird and is finely speckled with white or cream-buff. The length is $8\frac{1}{2}$ inches, being 1 inch less than the length of

the male red-winged blackbird, which is sometimes called a starling. The real starling has longer wings and a shorter tail than the redwing.

For centuries starlings have been accustomed to live about human habitations in Europe, where many people are pleased to have them around. Since 1890 they have spread from New York City and have become numerous in various localities in several states, a few having reached Ohio in 1916. They destroy cutworms and grasshoppers, but they also eat cherries and other fruits, steal the food of hens, soil buildings and sidewalks, and break up the nests of other birds. It is feared that they will rapidly spread over many states they have not yet reached. Several of the finest song birds of Europe have been liberated in Australia or New Zealand and have there become a great nuisance. It is hard to foresee how the habits of birds and other animals will become altered in a new region, where food, enemies, and climate are different from those to which they were accustomed in their native land.

CHAPTER NINETEEN

THE FLYCATCHERS

ALL the birds which have previously been described are classed as song birds, although some of them are hardly musical. Those that we shall study in the remaining chapters of the book are not song birds. Among these the flycatchers are a prominent family. Their voices are not so well developed as are usually those of the song birds, but the notes of some of them are quite pleasing. The beak has a wide gape, and there are spreading bristles at the sides of the mouth which make the mouth well adapted for seizing the flying insects on which they feed.

The kingbird. The kingbird is smaller than the robin. Its upper parts are quite dark colored and its under parts white or nearly so. The tail is broad at the end and shows a white terminal border that makes a strong contrast with the rest of the tail and the back. On the middle of the head is a bright orange-red crown, which is concealed by other feathers except when the bird wishes to display it. The crown suggests the name of this species, but the kingbird also dominates



U. S. Dept. Agriculture

FIG. 215. The scissor-tailed flycatcher.

birds much larger than itself, often chasing crows and hawks if they come near its nest. They do not molest little birds, and these are safer in the vicinity of a kingbird's nest than they would be if the kingbird were absent. Because of their skill and courage in driving away crows and hawks, kingbirds are useful to the poultry raiser.

Like other flycatchers, kingbirds feed on winged insects. Their method of capturing them is different from that of swallows and swifts. Instead of circling about on the wing, the kingbird waits on a conspicuous perch until an insect flies near. Then it darts after it and soon comes to rest again either on the same perch or on one not far away. The broad tail, used as a rudder, enables the kingbird to turn quickly in order to seize a fly in its beak. It is this ability to dodge which makes it safe for a kingbird to pursue and harass a bird of much greater strength.

Kingbirds are sometimes known as "bee birds" or "bee martins." By far the larger part of the bees they eat are drones. Robber flies (insects with long and slender tapering bodies) prey upon honeybees, catching them on the wing. These flies are eaten in considerable numbers by kingbirds, which in this way benefit the beekeeper. The kingbird eats wasps, flies, beetles, grasshoppers, butterflies, and caterpillars, taking some of them from the ground. Few American birds are more widely distributed or easier to recognize.

Does the kingbird arrive at your home before the first of May? Why does it not remain in the United States throughout the year? Do you think the bright color

on the crown attracts insects? Did you ever see a kingbird eat anything besides insects?

The Arkansas kingbird. The Arkansas kingbird is generally distributed in the western half of the United States. Like the other members of the flycatcher family, it does much good and scarcely any harm. An examination of sixty-two stomachs showed that insects composed most of the food. Honeybees were found in only four stomachs. Of the thirty bees found, all but one was a drone. As the worker bees kill the drones, the kingbirds may be said to assist them.

The phoebe. The phoebe or pewee is $1\frac{1}{2}$ inches shorter than the kingbird, having a length of 7 inches. Its upper parts are grayish brown, its under parts nearly white. It is best recognized by the constant dropping and flirting of the tail.

The phoebe has no song, but utters a monotonous *see-hee* or *see-bee*. It nests under bridges or on ledges of rock or in buildings, especially those near the water, and is usually to be seen in the vicinity of its nest. One pair started six or seven nests on the rafters under a shed roof. They finally finished one, leaving some of the others almost finished, some just started. They catch gnats, mosquitoes, flies, cucumber beetles, cotton-boll weevils, and other injurious insects.

The wood pewee. The wood pewee is still smaller



U. S. Dept. of Agriculture

FIG. 216. Phoebe or pewee.

*Finley & Bohlman*

FIG. 217. Young black phoebes.

than the phoebe. It shows some olive color both above and below and distinct whitish wing bars. Its habit of darting after flying insects and coming to rest again in a few seconds will help you to identify it as a flycatcher.

The sweet call of the wood pewees, coming from the trees in the woods or along a city street, is a pleasing sound. They spend little more than a third of the year in the Northern states, going to South or Central America for the winter.

Other flycatchers. The family of the kingbird and pewees includes about 400 species of flycatchers, all of them American. In the Old World are numerous species of flycatchers that belong to a different family. The various American flycatchers resemble in habits those that have been described, but most of them are to be found only in warm regions where insects are abundant throughout the year. The phoebe is the only one of the 400 species that winters in the eastern part of the United States north of southern Florida. In the spring it reaches the Northern states earlier than our other flycatchers.

CHAPTER TWENTY

HUMMINGBIRDS AND SWIFTS

THE hummingbirds and swifts belong to different but related families. They are birds of rapid flight. Their narrow and pointed wings sustain them in the air even when they are taking food. Over the greater part of the United States there is only one kind of hummingbird and one species of swift.

Hummingbirds. Few birds are so well known as the hummingbirds. As they hover over sweet blossoms their diminutive size and wings, rapidly vibrating, make them seem as much like insects as birds. In the eastern portion of the United States and Canada we have only one kind, the *ruby-throated hummingbird*. Small as they are, some individuals of this species go north in summer as far as Hudson's Bay. Some winter in the extreme southern part of the United States; others as far south as South America, where there are some 400 species of this family. Another species goes north in spring along the Pacific Coast to British Columbia, and a dozen or more kinds cross the Mexican border into our Southwestern states. There are no hummingbirds in Africa, Europe, Asia, or Australia.



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FIG. 218. Long-billed hummingbirds. This is one of the many species of hummingbirds found in tropical America.

Hummingbirds have very slender beaks, small feet, and long, narrow wings. Some kinds are 7 inches long. In fact, in one species two of the tail feathers reach this length. Other kinds are smaller than the ruby-throated hummingbird or birds of any other family. They differ greatly with regard to the shape and length of the bill and tail.

The dazzling brilliancy of the plumage of the hummingbirds in the full sunlight is like that of jewels. Different kinds have been named after various precious stones. The colors are remarkable for their brilliancy and variety. The upper parts of our ruby-throated hummingbird are green. The throat of the male sparkles like a ruby when the light is reflected at the proper angle, but in other positions it appears quite dull. Many other kinds of hummingbirds show similar changes in the appearance of the plumage of the throat and also of other parts when the direction of the light changes. The color is due to the structure of the feathers. In most kinds of birds the bright colors are due to pigment in the feathers, and this fades on long exposure to strong light. The bright colors of hummingbirds do not fade. The author has specimens of beautiful kinds which were brought from South America more than three quarters of a century ago.

Hummingbirds obtain from flowers both insects and nectar. The plants they visit are benefited by having their pollen carried from one flower to another. Can you tell what color of flowers attracts them most? Think of the kinds of flowers on which you have seen them. Do they ever enter an open window? Do they

show much fear of other creatures? Are they quarrelsome? Did you ever hear one utter a sound?

They have been known to take sugar held between the lips of a person, and nectar from a flower held in the hand. Their nests are dainty affairs not easily discovered. They are saddled on a limb at a height of 20 feet, more or less, from the ground and are covered with lichens like those on bark. The tiny nest is lined with plant down and contains two pure white eggs, each $\frac{1}{2}$ inch long. The young hatch in 2 weeks and are fed with minute insects which the mother has swallowed and regurgitated. The male, it is said, is never seen near the nest after the eggs are laid.

The chimney swift. These birds are commonly called "chimney swallows," but this name is objectionable, for the swift, although it resembles the swallows somewhat in its habits, is not related to them. The whole bird is the color of soot. It weighs less than an English sparrow. It has smaller feet and a shorter tail, but much longer wings. Its feet are used only for clinging, and in doing this it is aided by its tail feathers, which are stiff and have spiny tips. It does not alight on the ground or perch in a tree, but spends its time on the wing when not in a chimney or some similar retreat. Swifts commonly fly higher than most kinds of swallows. Like the purple martin, they are common in towns. When both swifts and martins are in sight at the same time, you can distinguish the swifts by their smaller size, sickle-shaped wings, shorter tails, and more rapid wing strokes. They subsist entirely upon flying insects.

At what time of day are swifts most active? How

many have you seen entering one chimney? Do they ever get burned? Do they ever come down into a room? Where did they nest before there were chimneys in this country? Do any of them use other nesting places now? Do swifts do any good or harm? Can you distinguish them from swallows by their notes? Do they merit the name "swift"?

Swifts winter south of the United States. Before leaving for the South they sometimes form large flocks. When do they leave your locality?

"With troops of fledglings catching their winged prey as they go, and lodging by night in tall chimneys, the flocks drift slowly south, joining with other bands, until on the northern coast of the Gulf of Mexico they become an innumerable host. Then they disappear. Did they drop to the water or hibernate in the mud as was believed of old, their obliteration could not be more complete. In the last week in March a joyful twittering far overhead announces their return to the Gulf Coast, but their hiding place during the intervening five months is still the swifts' secret."

WELLS W. COOKE

The nest of the chimney swift is composed of twigs which are glued together and to the inside of the chimney with saliva. The twigs are snatched from trees while the bird is flying. In the East Indies are other species of swifts which build nests in caves and on sea cliffs. The Chinese value these nests very highly, sometimes paying their weight in silver for them, for making their bird's-nest soups. What the Chinese want is the saliva used by the bird to glue together the fibers of the nest and make it adhere to the wall, and not the fibrous material that is used.

CHAPTER TWENTY-ONE

THE GOATSUCKERS

GOATSUCKER is a curious name for birds that feed entirely on insects. Their beaks are small but their mouths open very wide, and some kinds, like the whippoorwill, have long, stiffened bristles bordering the mouth opening, making a sort of insect net.

There are many kinds of goatsuckers in the tropics of both hemispheres, but in the United States the family is represented mainly by the nighthawks and whippoorwills. They are in-

teresting birds, but unfortunately are no longer common, although the nighthawks have in some places increased in numbers during the last few years. They should be protected, for they do much good and no harm.

The nighthawk. The nighthawk spends the winter in South America and arrives rather late in the spring at its summer home in the United States and Canada. They are not hawks, as you would naturally think from their name. Their feet are small and not at all adapted to seizing prey, nor are their beaks adapted to tearing flesh. They feed entirely on insects which they catch as they fly, and so are useful to man. Fifty different kinds of insects have been found in the stomach of a single nighthawk. Their bill of fare includes malaria-carrying mosquitoes, flies, moths, cotton-boll weevils, potato beetles, squash bugs, June bugs, and various

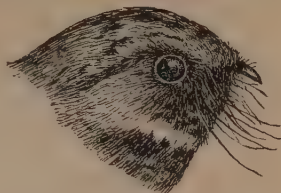


FIG. 219. Head of whippoorwill. When the mouth is opened, the stiff bristles bordering it form a net for catching insects.

*Finley & Bohlman*

FIG. 220. Nighthawk. The nighthawk lacks the conspicuous bristles of the whippoorwill.

other dainties we are willing they should have. In some places they are popularly known as "bull bats."

If once you learn to recognize the loud, nasal *peent* of the nighthawk, or the peculiar booming sound made by their wings when from high in the air they swoop down to near the ground, your attention will often be called to them both in town and country. They rarely fly near enough to afford you a good view of their color, but a large white patch on the otherwise dark wings is very prominent. When the birds are overhead, these white patches make the nighthawks' wings look as if there were large openings through them. Like the swifts, to which they are related, nighthawks fly with wonderful swiftness. Their aerial evolutions might suggest an exhibition of flying by an expert aviator,

but seem to be made with ease and much of the time in silence. Their wings are so long that when folded they extend beyond the end of the tail. When expanded they make the birds appear larger than robins or jays, although they weigh much less.

The nighthawk does not perch, but rests on its breast lengthwise on the limb of a tree. It flies at various hours of the afternoon and sometimes earlier, but is most often seen between five o'clock and dark. It builds no nest, but lays two eggs on the ground in fields or open woods, or, rarely, among the pebbles of the gravel-covered roofs of business blocks in cities. The eggs are regularly elliptical, having the two ends alike. They differ in color, but are blotched or finely speckled with brown or gray. If the mother bird is disturbed, she will move the eggs to a new location.

The whippoorwill. The whippoorwill resembles the nighthawk, but should not be confused with it. The two species are much more easily distinguished from each other than are our various species of sparrows. The whippoorwill's wings show no white patches and do not reach nearly to the tip of the tail. The end half of the three outer tail feathers is white, and there is a band of white across the breast. The upper parts of both birds are dark colored, but so mottled as to harmonize with dead leaves and other litter on the ground.

Instead of soaring high in the air in search of food, whippoorwills catch moths and beetles in the woods and bushy fields. The two eggs are laid on the ground in the woods, without any nest. They are shaped like those of the nighthawk, but have obscure lilac markings.



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FIG. 221. Chuck-will's-widow. A Southern relative of the whippoorwill.

The nighthawk does not, as some have supposed, make the call *whip-poor-will*. This note, with the middle syllable slighted and the first and last strongly accented, is uttered only by the whippoorwill. It may be heard, at different hours of the night, coming from woods sometimes half a mile away.

The *chuck-will's-widow* is a member of this family found very abundantly in many of the Southern states. It is larger than the whippoorwill and has a wing expanse of 2 feet. Its mouth and gullet open so wide that it can swallow small birds, although it feeds mainly on insects. In the Southwest the *poorwill* takes the place of the whippoorwill of the East.

CHAPTER TWENTY-TWO

THE WOODPECKER FAMILY

THE woodpeckers can easily be distinguished from other birds by their wavering flight and their habit of drilling holes in trees. They spend much time on dead limbs where there is no foliage to conceal them. Most kinds show some bright red color on the head of the male, and many species on the head of the female also. Many have conspicuous white patches sharply contrasted with black or brown. They do not sing, but have loud call notes more or less pleasing to the ear. In most parts of the country several species of woodpeckers may be seen, three or more of them at any time of the year. They drill into wood for grubs, which they extract with their stiff, barbed tongues.

Nests of the woodpeckers. For nests woodpeckers make holes in tree trunks or limbs. These lead inward a short distance and then down several inches, or, in the case of the larger species, more than a foot. On the chips at the bottom are laid the white, unspotted eggs. When they are not nesting, they resort to shallower hollows for protection at night and during storms.

Adaptations to mode of life. Examined closely, a woodpecker will be seen to be well adapted to its mode of life. Unlike any of the birds previously studied, they have only two toes in front, the fourth or outer toe being turned back to aid in grasping the bark (Fig. 222). The hind toes are longer than those of most birds, and all the claws are sharp and strongly curved. The legs are short. The tail also is used to support the bird as it clings to the side of a tree and is adapted to this purpose,

the tail feathers having stiff shafts and pointed tips that do not slip when applied to smooth bark. The central



FIG. 222. Beak, tongue, and foot of woodpecker.

tail feathers are longest. Does this adapt the tail to a curved surface? The beaks of woodpeckers may be compared to drills or picks and their tongues to spears. Their skulls are hard and thick and their necks slender, enabling them to give force to every blow. In some species the outlines of the beak are almost perfectly straight. Its strength is increased by ridges running lengthwise of the beak. The tongue of an ivory-billed woodpecker is about $6\frac{1}{2}$ inches long, but cannot be protruded nearly this distance beyond the end of the bill.

The downy woodpecker. The downy woodpecker is very widely distributed. It is smaller than the other members of its family, and is neither so common nor so conspicuous as some of the other species; yet it is often seen both in town and country. When clinging to the under side of a low limb, pecking vigorously in search of grubs, it may easily be watched at close range. In winter, when other birds are scarce, its cheerful note and the bright scarlet on the back of the head of the male enliven the scene. Few birds are more useful. It not only cheers us, but it also renders valuable service by extracting borers from trees. Downy woodpeckers drill into the cocoons of *Cecropia* moths and devour the

pupæ. They eat the larvæ of the codling moths or "apple worms." The little fruit they eat consists of frozen-thawed apples and wild berries.

The hairy woodpecker. The hairy woodpecker is distinguishable from the downy woodpecker less by its color than by its larger size. In many localities it is not so common as the downy woodpecker. Both have the under parts white and a broad patch of white along the middle of the back, although the upper parts are mainly black. Their habits are similar.

The red-headed woodpecker. The red-headed woodpecker is one of the most common and conspicuous birds in the wide region extending from the Hudson River to the Rocky Mountains. It is not so common in New England. In the Northern states only a few of these woodpeckers are seen in winter, and they do not become very common until about the first of May; but where beechnuts are abundant many of them remain through the winter. Both sexes of this species are colored alike. The whole head is gray in the young and crimson in the adult birds. The extensive white of the lower back and wings makes a strong contrast with the black that extends forward to the neck.

Unlike most woodpeckers, the red-heads eat more vegetable than animal food. This includes corn in the milk, acorns, beechnuts, cherries, and various berries, both wild and cultivated. They obtain insects not only from the trees but also at times by darting after them in the air. Many of the insects eaten by them are tiger beetles and ground beetles which are useful to man; but they also eat cankerworms, which do much damage

in orchards. The red-headed woodpeckers have the bad habit of sometimes eating the eggs and young of other birds. Their bright colors and loud calls may excite our admiration, but some of their habits give ground for prizing them less than other kinds of woodpeckers. They drum on telephone poles and roofs, as well as on dead trees. Apparently they enjoy the sound; or they may be communicating with others of their kind, which can be heard to respond in a similar manner.

The California woodpecker. The California woodpecker belongs to the same genus as the red-headed woodpecker. It is famous for making numerous holes in the bark of spruce and other trees and inserting an acorn in each hole so securely that neither other birds nor squirrels are likely to get it out. Thus a store of food is provided that can be utilized when acorns on the ground are buried beneath the snow.



Finley & Bohlman

FIG. 223. California flicker. Note how the bird supports itself with its tail.

The flicker. This woodpecker is often called the yellow-hammer or high-hole, or by one of many other names. It is the largest of the common woodpeckers, and has a white rump which helps an observer to recognize the bird as it flies away.

Both sexes have a broad black crescent across the breast and bright scarlet on the nape, but the female has

no "mustache." These marks on the sides of the face of the male are black in the flicker of Eastern North America, but scarlet in one of the flickers of the West. This Western flicker differs also in having little or no red on the neck and golden red on the under side of the wings and tail, so that it is called the "red-shafted flicker." The wings and tail of the Eastern flicker are yellow beneath, so that it is called the "golden-winged woodpecker." Its back is brownish gray, barred with black.

Flickers subsist largely on ants, getting many of them from the ground. Their beaks are more curved and pointed than the beaks of our other woodpeckers and are not so well adapted to drilling into trees. Like other kinds of woodpeckers, they eat fruit, including the berries of the poison ivy.

The antics of flickers during courtship are quite amusing. For a nest they excavate in a tree trunk or limb a good-sized hole, where the female lays five to nine eggs. The nestlings are fed by a parent thrusting its beak into the throats of the young and pumping in partly digested food from its own stomach.



Joseph H. Dodson

FIG. 224. A house for flickers.

Have you known flickers to make openings through the roofs or sides of a building? Do they ever drum on metal? Do they often occupy artificial nesting sites?

The yellow-bellied sapsucker. The amateur may mistake this woodpecker for the downy or hairy woodpecker. It is larger than the former and smaller than the latter. It differs from both in having the crown of both sexes crimson, though not always so in the female. In the downy and hairy woodpecker there is less red, the red is farther back, and is found only on the male. The male sapsucker has the throat red, the female has it white. A white stripe runs lengthwise on each wing, but there is no broad white stripe along the middle of the back as in the downy and hairy woodpeckers. The sapsucker differs from these also in having a slight yellowish tinge to the plumage.

Sapsuckers spend the summer in Canada and the northernmost states, and winter from the Ohio Valley to the Gulf. Many people have a chance to see them only in the spring or fall, when they are migrating and are likely to be very noticeable.

If there is a variety of trees within a short distance of your home, you will not need to search long to find one that shows holes made by sapsuckers. A single apple, birch, or cedar tree may show more than a thousand holes made by sapsuckers in the course of years. In April or May you can see fresh holes among them. Perhaps your attention will be attracted by a large area of bark wet with sap. At the top of this wet area you will see sapsuckers' holes. They extend merely through the bark. After visiting one set of holes and drinking

the sap, a bird may visit another tree it has tapped and then a third, after a time returning to the first and drinking the sap which has refilled them. When the sap flows fast enough, a sapsucker will sometimes remain for hours at one spot.

Notice whether the rows of holes are more likely to run up and down or around the trunk. If you consider the direction in which the sap is moving before the tree is tapped, you can tell whether more would flow out from a given number of holes arranged in a vertical or in a horizontal row. Do you find them arranged so as to cause the largest flow of sap?

The sapsucker holes, although neither large nor deep, injure the trees in two ways: first, they cause the loss of quite a quantity of sugar which the leaves have made for the nourishment of the tree; and secondly, they interrupt the channels through which this sweet sap can flow down to nourish the roots or be stored for the future needs of the tree. Girdling by sapsuckers has caused the death of some trees.

Indirectly the sapsucker is harmful in still another way. It gives the woodpeckers a bad reputation. Just as hawks and owls in general must suffer because some kinds catch chickens, and snakes in general suffer because some kinds are able to inflict poisonous bites, so woodpeckers in general are likely to bear the blame for damaging trees because one kind does damage them. The woodpeckers do not deserve this evil reputation; among them are some of our most useful birds, and these merit protection, even though they eat some fruit from cultivated vines and trees.

CHAPTER TWENTY-THREE

THE KINGFISHER



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FIG. 225. Young kingfishers.

IN the Malay Archipelago are many kinds of beautiful kingfishers, but in North America, north of southern Texas, we have only one species of this large family. It is 13 inches long and is considerably larger than a robin. Its upper parts are bluish gray. It is easy to distinguish it by its crested

head and long, stout, straight beak. As it flies it utters a loud, harsh, rattling cry.

The kingfisher lives along a stream. Perched on a branch overhanging the water, it watches for fish. When it espies one it slips off its perch, plunges headlong into the water, and seizes the fish in its beak. Rising into the air again, the kingfisher shakes the water from its oily plumage and returns to its perch. There it tosses the fish up into the air, catches it, and swallows it head first. Sometimes a kingfisher, while flying over the water, darts down upon a minnow that attracts its attention. Each pair fishes in a certain portion of the stream, and kingfishers seldom trespass on their neighbors' preserves.

The kingfisher tunnels into a vertical bank about 6 feet, and at the inner end of the tunnel lays five to eight white eggs. These birds often remain in the North until the streams are partly covered with ice. After August they are solitary; that is, each one lives by itself.

CHAPTER TWENTY-FOUR

THE CUCKOO FAMILY



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FIG. 226. The road-runner, a Southwestern bird of the cuckoo family. It runs along a road, easily keeping ahead of a horse that is trotting briskly.

OUR cuckoos are about a foot long but very slender, their tails making half of the whole length. Their color is grayish brown above and dull white below. The *yellow-billed* and the *black-billed cuckoos* are the only species to be seen north of Florida. The yellow-billed cuckoo differs from the other species in having the bill partly yellowish instead of entirely black, and in having the ends of the tail feathers white for a much greater length.

Cuckoos are more often heard than seen, for they usually conceal themselves in foliage when they are not flying. They arrive later in spring than do most of the summer residents, — not until many kinds of trees are in leaf. Their notes are so different from those of any of the song birds, that you might suppose the sound issued from the throat of a frog rather than of a bird. Their cry sounds like *Kuk-kuk, kuk-kuk, kuk-kuk*; at other times, *Cow, cow, cow*. The black-billed cuckoo



FIG. 227. Young road-runner.

has a softer voice than the yellow-billed. Cuckoos are known as "rain crows," because they call principally in damp or cloudy weather. Careful observers believe that they foretell the weather. The name "cuckoo" is derived

from the note of the European cuckoo, which is imitated by the cuckoo clocks.

The female European cuckoo, after laying an egg on the ground, takes it in her beak and deposits it in the nest of a smaller bird, giving no further attention to the egg or young. It is a plain-colored bird for the same reason that a female cowbird is plain colored.

Many other species of cuckoos lay their eggs in other birds' nests, a practice which is shared by some individuals among our American cuckoos. However, our cuckoos usually build a shallow and flimsy nest of small sticks and grass in a tree or vine-covered bush. Their pale greenish-blue eggs are laid at such long intervals that the first may hatch while the last is still fresh.

In Africa and in the East Indies are many kinds of cuckoos, some of them brilliantly colored. The family includes nearly 200 species. They resemble the woodpeckers in having two toes in front and two behind. Their beaks are curved. Some kinds eat reptiles as well as insects. Our two species eat caterpillars such as the tent caterpillar and web worm, so that they are highly useful, especially in orchards.

CHAPTER TWENTY-FIVE

BIRDS OF PREY

OWLS and hawks are birds of prey ; that is, they seize other living creatures and devour them. Their claws, or talons, are strong, curved, and very sharp. The beak, when closed, has the upper mandible curving down over the lower. Their wings, when spread, have a great expanse, and the muscles that move them have great strength. Their broad tails enable them to change their course quickly. Their keen sight and sensitive ears detect the motion of a mouse or the chirping of a sparrow. In every way they are adapted to capturing prey.

OWLS

Several kinds of owls occur in most districts ; yet few people have an opportunity to see them, for most of them remain in seclusion through the day. They may be distinguished from other birds by their large eyes directed forward ; in order to look around or to one side an owl must turn its head. The female is usually larger than the male, but both are of the same color. Several species of owls remain in cold regions throughout the winter. As they hunt chiefly at night, they need to be well protected from cold ; even their legs are well covered with feathers. Some kinds of owls are large enough to carry off a full-grown cottontail rabbit or a hen.

When an owl extends its legs to grasp an animal over which it is flying, the toes spread out. When the legs are drawn up, the toes close. The outer toe is capable of turning either way, so that when perching the bird may have two toes behind the perch, or one behind

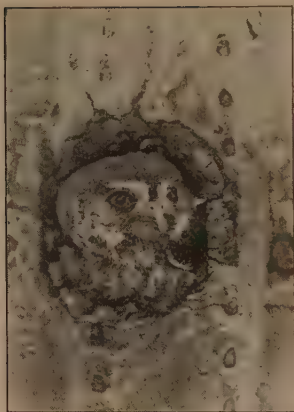
*Finley & Bohlman*

FIG. 228. Elf owl looking out of his hole in a giant cactus.

and three in front. Their feathers are soft and downy, and their flight is noiseless. They feed largely on mice. After digesting the meat, they eject the bones and hair from the mouth in a round pellet. An examination of 200 pellets ejected by barn owls showed the remains of 225 meadow mice, 179 house mice, and 20 rats.

The screech owl. Screech owls are found throughout most of North America and are more common than other kinds of owls. They may be distinguished from other owls by their small size and conspicuous tufts of feathers over the eyes. They are less than 10 inches long. Their plumage is mottled, but the colors differ with individual birds; some are mainly gray, others mainly reddish brown. One spring I saw three half-grown screech owls, all of the same size, sitting side by side on the limb of a tree. No doubt all had come from the same nest, yet two were red and the other one was gray. These color phases do not depend on age, season, or sex.

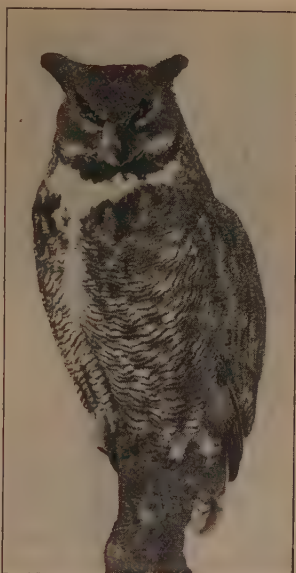
Screech owls nest in hollow trees along a city street or in an old orchard, as well as in the woods. They occupy these holes also for protection or to avoid being molested during the day by jays and other birds that make a great fuss over owls. The screech owls are much

more useful birds than jays; of 255 stomachs examined, only one contained poultry. Three fourths of their food consists of injurious mammals, such as mice, and of injurious insects. The birds they catch are mainly English sparrows. For this reason, if for no other, this owl should be welcome to a home in any town or on any farm where English sparrows are a nuisance.

These little owls do not screech, but utter a quavering whistle. In the South people call them "shivering owls."

The great horned owl. The great horned owl is nearly 2 feet long and gets its name from its large size and the tufts of feathers over its eyes. Formerly it was common in dense woods throughout North America. Now stuffed specimens are more likely to be seen than living ones, unless one visits zoölogical gardens or city parks where collections of birds are kept.

The nesting season of the great horned owl is very early — in February or March. The nest is made in the hollow of a tree or on the top of a stump, or a bulky nest of sticks is built on the branches of a tall tree in the deep forest. The eggs are white, two to four



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FIG. 229. Great horned owl.

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FIG. 230. Barn owls.

in number, and nearly spherical, the greater diameter being more than 2 inches. The young are covered with gray down.

The great horned owl kills and devours a large variety of animals,—mice, rabbits, reptiles, fish, and insects, as well

as crows, large hawks, owls, wild ducks, doves, bobwhites, half-grown turkeys, chickens, and guinea hens. Although it does some good by killing creatures that are injurious, yet it destroys so much poultry that we must consider it at times, at least, a harmful bird.

The barn owl. Owls in general are so unusual as to attract a good deal of attention, but the barn owl, or “monkey-faced owl,” is peculiar even among owls. It has conspicuous disks of feathers radiating from the eyes and setting off the face from the surrounding plumage. Its color is bright reddish brown, the under parts showing a good deal of white. In size it is intermediate between the screech owl and the great horned owl.

Most kinds of owls spend the daytime in the woods, but the barn owl is sometimes found in large numbers inhabiting a church steeple, a town hall, or other building where its presence had not been suspected. It is generally distributed over the United States except in the northern part. Flying only at night, it is not often seen. It is one of the most useful of birds. It lives al-

most entirely on rats and mice and eats very few birds and scarcely any poultry.

Other owls. Several other owls are widely distributed in North America. Of the large ones the *barred owl* is the most common. It lives in the woods, and I have known of per-

sons' mistaking its loud hooting for the howling of wolves. The *snowy owl* visits the Northern states in winter. It is as large as the great horned owl. Its plumage is white, barred with brownish black. In the whole world there are some 300 species of owls. Some bird students think that they are related to the goat-suckers more closely than to hawks.



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FIG. 231. Young burrowing owls. These Western owls live in holes in the earth.

HAWKS

Hawks have the characteristics given at the beginning of this chapter for birds of prey, but they lack the peculiar features of the owls. They hunt in the daytime. Their eyes are directed sideways, as is common in birds, and not forward like the eyes of an owl. Their feet are not feathered; each foot has one toe behind and three in front.

The sparrow hawk. This is the smallest and most common of the hawks. It is but little larger than a robin. It may be known from other birds of similar size by its

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FIG. 232. Young red-tailed hawks. The nest is in a giant cottonwood 120 feet from the ground.

long wings, square tail, and reddish brown color, the male having the wings partly ashy blue. Some of them live in towns, feeding on English sparrows and taking shelter at night in a cornice or other part of a building. In the country they may be seen flying over the fields, or hovering over a spot in the grass where their keen eyes have detected something moving. When they alight it is usually in a conspicuous place, where they can watch for something to eat. In summer they subsist largely on grasshoppers and crickets and in winter on meadow mice and house mice. They eat so few useful birds and young chickens that on the whole sparrow hawks are beneficial.

The cry of the sparrow hawk is shrill and quickly repeated, *killy, killy, killy*. They are known also as "killy hawks" and "rusty-crowned falcons." They nest in hollow trees and retain the same mates throughout life.

Other hawks. Several other kinds of hawks are to be seen in most localities, but they are becoming scarce in thickly settled regions. This is unfortunate, not merely because they are interesting birds to watch, but also because the majority of them benefit the farmer by catching mice, grasshoppers, or other pests. If only

those hawks were killed which the farmer has seen catching his chickens, no one need complain. The intelligent farmer knows that two species of hawks, the *Cooper's hawk* and *sharp-shinned hawk*, deserve blame for most of the loss of poultry due to hawks. The two are colored alike, but Cooper's hawk is the larger species.

Male hawks are usually smaller than females. In some species the sexes differ in color. Moreover, both change their appearance as they grow older. Few persons are able to identify by color every specimen of hawk that is shot in the neighborhood, and fewer still can distinguish the various species when flying. Bounties should not be offered on either hawks or owls, for such bounties cause the death of many valuable birds.

Other birds of prey. Eagles, kites, and falcons are similar to hawks and related to them. They all have talons for seizing prey and a hooked beak adapted to tearing flesh. Many of them are of large size. The wings of a fish hawk, or osprey, when stretched out measure about $4\frac{1}{2}$ feet from tip to tip; those of eagles 6 or 7 feet; and those of some of the Old World vultures, the condor of the Andes, and the California condor, — all of them birds of prey, — more than 9 feet.



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FIG. 233. Young golden eagle.

CHAPTER TWENTY-SIX

THE MOURNING DOVE

OVER a large part of the United States and Canada the mourning dove is now the only kind of wild pigeon to be seen. Its upper parts are olive-grayish brown, its tail long, pointed, and bordered with white at the end. It is sometimes called the "turtle dove," but the real turtle dove lives only in the Old World.

Mourning doves mate early in the spring and commonly rear two or more broods of young. The nest is a nearly flat platform made of a few twigs, weed stalks, and straws, placed in one of the lower branches of a tree. Sometimes the two white eggs are laid on the bare ground. The father takes care of the young doves, while the mother incubates the eggs for another brood.

The cooing of this dove is easily distinguished from other bird notes. It is audible at some distance, but the bird is not so far away as the listener would judge from the sound. To some the cooing seems mournful, but it is really a love song.

Mourning doves eat weed seeds and scattered grain. In a single stomach were found 6600 seeds, most of them seeds of troublesome weeds. Like chickens, doves swallow gravel to aid in grinding their food. By some they have been treated as game birds, but they are much more useful alive than dead, and should be protected.

Do any mourning doves stay near your home through the winter? How are the young fed? How early in the year do they begin to nest, and how late do they rear their last brood? Did you ever see one far from its mate?

CHAPTER TWENTY-SEVEN

THE BOBWHITE

THESE birds are commonly called "quails." They show some resemblance to the meadowlarks in their habits and in the color of their upper parts, which are rich reddish brown or chestnut mottled and streaked with blackish and with paler colors. They are shorter than meadowlarks but are heavier, being shaped more like a hen. In fact, they belong to the

Gallinæ, the order to which chickens, grouse, partridges, peacocks, and pheasants belong, while the meadowlark is one of the *Passeres*, or perching birds. Bobwhites spend all their time on or near the ground. They frequent meadows and grainfields, where they are very useful in destroying potato beetles, chinchbugs, inchworms, spanworms, grasshoppers, and other destructive insects. In cold weather they eat quantities of weed seeds. At no time do they damage any crop. Their color harmonizes so well with their surroundings that they are often difficult to see until they fly. Their clear whistle, *bobwhite*, is easily imitated, and boys often amuse themselves by whistling and waiting for a response.



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FIG. 234. California partridge, a close relative of the bobwhite.



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FIG. 235. Ring-necked or Chinese pheasant, a relative of the partridges. It has been introduced into the United States, and is to be found wild in some localities.

The flesh of the bobwhite is much liked, but to the farmer these birds are more valuable alive than dead. Several states have passed laws to protect bobwhites for periods of several years, without any open season. With such protection they become numerous. The nests are on the ground and contain ten to eighteen eggs. The young, like little chickens, are able to run as soon as they are hatched.

Bobwhites are among the few birds that spend their lives in the same region where they are

hatched. Sometimes they perish in winter, imprisoned beneath a crust that forms on top of the snow which has drifted about them. The bobwhite, like all the members of its order, has the hind toe elevated so that it does not touch the ground.

CHAPTER TWENTY-EIGHT

WATER BIRDS

THE water birds, like the land birds, belong to several different orders. The ducks and geese are adapted for swimming, the herons for wading, the plovers for getting food from mud flats, and the gulls and terns for picking up food from the water while flying over it. The birds of these four orders differ greatly in appearance, nor do they resemble loons, pelicans, or rails, which belong to still other orders of water birds.

Possibly more than fifty species of water birds fly within a few miles of your home when they are migrating, but unless you live near a river or some large body of water you may not have a chance to see a dozen species in a whole year.

SHORE BIRDS

The killdeer. The killdeer is not much larger than a robin, but its wings are so long that when seen in flight the bird may appear almost as large as a pigeon. Its bill shows some resemblance to a pigeon's, but killdeers are on the whole quite different from any of the birds previously described. They belong to the *Limicolæ*, one of the orders of water birds. They have moderately long, bare legs and have no hind toe. They do not perch upon or cling to branches or trunks of trees, but, when not flying, are to be seen on damp ground or in shallow water. Their four large eggs are placed with the small ends pointing toward the center of the nest, which is on the ground, sometimes near water, sometimes in a pasture or corn-field. The young are able to leave the nest as soon as



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FIG. 236. White heron habitat, South Carolina.

they are hatched. The loud call which gives the killdeer its name may be heard in the Northern states quite early in the spring. Some of them winter north of the Ohio River, others as far south as Peru.

Killdeers are very useful birds. They eat crayfish, mosquito larvæ, horse flies, cattle ticks, crane flies, grasshoppers, crickets, cotton worms, cutworms, tomato worms, alfalfa weevils, cotton-boll weevils, clover-root weevils, clover-leaf weevils, rice weevils, cowpea curculios, grapevine-leaf beetles, and insects that feed on corn, sugar cane, apples, sweet potatoes, sugar beets, carrots, and various other useful plants. They eat also a kind of worm that preys on oysters.

The killdeer is a kind of plover. Several other species of plovers may be seen at the borders of pools or lakes or on sand bars or mud flats, especially in the migrating season.

The spotted sandpiper. The sandpipers belong to the same order but not to the same family as the plovers. Both sandpipers and plovers are shore birds, but the sandpipers have long, slender bills and are more like snipes than they are like plovers. They probe into the mud in search of food. They live along the seashore and the shores of lakes and streams.

Nearly a dozen kinds of sandpipers may be seen in the course of a season on the shore of a single lake. The only kind most persons know is the spotted sandpiper. This is often seen along little streams as well as on the shores of lakes and rivers. It is smaller than the killdeer and without conspicuous color marks. In fact, its back harmonizes so well with the color of wet sand that



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FIG. 237. A baby spotted sandpiper.

the bird is likely to escape notice except when it moves. Its under parts are white, spotted with black in the adult birds.

The spotted sandpiper may be known from birds of other orders by its long legs, slender beak, and its habit of bobbing or teetering as it stands or

wades in shallow water. It is called "tip-up," "teeter-tail," or, from its note, "peet-weet." Read Celia Thaxter's poem, "One Little Sandpiper and I."

The Bartramian sandpiper. The Bartramian sandpiper is often called "upland plover." Which name, sandpiper or plover, do you consider more appropriate for it? The long, bare legs show that it is one of the water birds, but it lives in cornfields, stubble fields, pastures, and prairies rather than about large bodies of water. Being highly prized as a table delicacy, it has been hunted until few individuals remain. But it deserves protection, for it feeds on weed seeds and insects, including those that injure corn, cowpeas, clover, cotton, and other crops.

In alighting, this sandpiper stretches its wings high over its back. When flushed it utters a soft, bubbling whistle. The song, given from the ground or a fence, will thrill any lover of nature who is fortunate enough to hear it, *ch-rrrr-ee-e-e-e-e-e-oo-o-o-o-o-oo*. "This prolonged, mournful, mellow whistle, more like the whistling

of wind than a bird's voice, may be heard even in the night and is one of the most weird and never-to-be-forgotten sounds in nature."¹

WADING BIRDS

The rail family. Rails are marsh birds, with short wings, bare legs, long toes to support them on the mud or on floating plants, and narrow bodies adapted to passing between reeds or rushes. In the springtime the marshes resound with their harsh cries. They do not probe into the mud, as snipes and sandpipers do, but take from the surface snails, crustacea, insects, and seeds. Their rude, flat nests on the ground or in a tuft of herbage are built of sticks, rush stalks, and grasses. The eggs are spotted and are usually six or more, sometimes fifteen in number. The young are covered with black down and can run soon after they hatch.

The largest of our species, the *king rail* or *fresh-water marsh hen*, is 15 inches long, with its wings $6\frac{1}{2}$ inches and its bill about $2\frac{1}{3}$ inches in length. Its back is variegated with olive-brown and blackish; its under parts are reddish brown. Of the same color but smaller is the *Virginia rail*, its wings only 4 inches long. The *Carolina rail* or *sora* is the most common species in the eastern and middle parts of the United States, but less common than the Virginia rail in the West. It is $8\frac{1}{2}$ inches long, a little smaller than the Virginia rail, and has a much shorter beak. Its upper parts are olive-brown, varied with black, with numerous sharp white streaks and specks; below it is mainly whitish.

¹Langille.



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FIG. 238. Sora, or Carolina rail.

When migrating, soras are sometimes seen in towns and appear remarkably tame. Many are killed by flying against chimneys and windows. When flushed from their nests in the marshes, this and other small rails are loth to take to wing and may be picked up alive. In autumn many soras frequent the floating weeds along the borders of rivers.

Coots and gallinules belong to the same family as the rails and are widely distributed. Both coots and gallinules have a curious horny frontal plate at the base of the bill. In the gallinule this is conspicuous because of its bright red color.

Coots, or *mud hens*, spend much of their time in flocks on the open water, like ducks, but seldom if ever dive. Their toes are widened by lobes of skin extending down the sides, but there is not a complete web uniting the toes, as in the foot of the duck. The beak is narrow from side to side, and it lacks the comblike edge that characterizes a duck's beak. The plumage of the coot is a dark bluish slate color, pale below.

The *Florida gallinule* is about 13 inches in length. It looks much like a coot, but its long toes are desti-

tute of lobes and its bill is red, tipped with yellow. These birds stay among the reeds and cat-tails and are heard oftener than seen. They breed throughout the greater part of the United States and south as far as Chile and Argentina.

The *purple gallinule* has the head, neck, and under parts of a beautiful purplish blue color. It is common in the tropical and warm temperate parts of America and has been seen north as far as the southern part of New England and the Great Lakes. It frequents ponds where the yellow pond lily abounds.

Cranes and herons. The birds belonging to the heron and crane families have long, bare legs, long necks, and long, straight beaks. The bird student can tell them apart by their tracks, for the hind toe of the crane is small and elevated, so that it leaves no trace. They are also distinguished by the fact that the herons in the breeding season have long, graceful plumes adorning the breast and back, while cranes lack these plumes. When flying, herons carry the neck folded and drawn in between the shoulders, while cranes have the neck as well as the legs outstretched.

Cranes are now seldom seen east of the Mississippi



Mrs. L. H. Toussaint

FIG. 239. Sand-hill crane.

*Am. Mus. Nat. Hist.*

FIG. 240. American bittern, a member of the heron family.

River except in city parks. They nest on the ground, and the young are able to run soon after they are hatched. They get part of their food from marshes, as herons do, but frequently from the uplands also. They eat vegetable food as well as field mice, snakes, lizards, and frogs. While migrating, they fly in long files.

When flying, herons can be told from most birds by their long, outstretched legs. When standing at the edge of the water waiting for a chance to

spear a frog, fish, or snake, the heron is apt to be so still as to escape the notice of a person near by.

One of the most common members of the family is the *little green heron*, which nests in trees in the vicinity of streams, usually each pair by itself. The *great blue heron* is often called a crane by those who fail to distinguish between the birds of these families. It builds for a nest a platform of sticks, usually in a large sycamore or other tall tree. Several of these broad nests may be built in one tree top, and formerly hundreds of them might be seen in one forest. In the breeding season the birds resort to the same heronry year after year. Oftentimes there is not more than one heronry, or breeding place, of the great blue heron in a county, and many

counties are without any. The herons go miles away in search of food. The young herons are fed by the parents for three or four weeks before they leave the nest.

The *white egret*, or white heron, breeds in the Southern states, but in summer it is occasionally seen farther north. During the breeding season it has beautiful long plumes, called "aigrettes," growing from the back between

the wings. In order to obtain these feathers to adorn the hats of heartless or thoughtless women, these beautiful birds have been almost exterminated by plume hunters, who slaughter the mature egrets and leave the helpless young birds without parents to care for them. In Florida two agents of the Audubon Society who tried to protect these birds were killed by the ruthless plume hunters.

TERNS AND GULLS

The graceful movements of terns and gulls, as they pursue their course with tireless wings, delight the eye of the ocean voyager as well as the visitor to large inland waters.



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FIG. 241. The Arctic tern, the world's migration champion. A distance of 11,000 miles separates its summer from its winter home.

CHAPTER TWENTY-NINE

MAKING GROUNDS ATTRACTIVE TO BIRDS



Joseph H. Dodson

FIG. 242. Grounds that are attractive to birds.

WITHIN the last few years appreciation of birds has led to efforts to protect them and enable them to increase in number. The United States Government has given the birds about seventy islands, lakes, and other bird reserves, for their exclusive use, so that they may rear their young unmolested, and the National Association of Audubon Societies guards with paid agents over one hundred of the most important breeding colonies of birds in the United States. In addition, private citizens have appropriated large tracts of land for the use of wild birds, and the grounds about thousands of homes have been made more pleasant by making them attractive to the feathered songsters.

Houses, food, drink, and safety for birds. Even in small yards, boxes or houses can be put up for birds to

occupy, sheltered feeding places can be provided and stocked with food in winter, and water supplied in dry seasons. A fountain with a shallow bowl where birds may drink and bathe will attract a great many, which may then be watched



R. E. Horsey

FIG. 243. A robin in a bird bath.

while they are having a good time. However, none of these things will be of much use if the birds are allowed to be killed by cats or driven off by English sparrows. Families that are unwilling to dispense with cats sometimes provide them with collar and bell to give the birds warning of the enemy's approach.

Planting trees and shrubs for birds. Where room permits, grounds may be beautified and at the same time made more attractive to birds by planting a variety of trees, shrubs, and vines. Smoothly trimmed hedges and stiff trees of a formal garden are not so attractive to them as untrained bushes and tangled thickets. Seclusion from real or imaginary foes, protection from wind and storm, as well as a supply of food and water, are advantages the birds derive from trees and shrubbery of the right sort.

The choice of the trees and shrubs to be planted must be determined partly by the climate. There are wild plants in every part of America whose fruit is relished by birds as much as is the fruit of cultivated varieties.

*R. E. Horsey*

FIG. 244. Making bird houses.

The planting of some of these wild varieties on the borders of orchards and vineyards oftentimes serves to protect the cultivated fruit. If selected for this purpose, the wild fruit should ripen at the same time as that which is to be saved. For the sake of the birds, various plants can be grown

whose fruit ripens at different seasons. A number of kinds are useful to supply food in winter.

Of plants that retain their fruit a long time, some of the best are the juniper, sumach, mountain ash, frost grape, roses, and in the South, the magnolia, china-berry, and holly. The mulberries, service berries, red-berried elder, European bird cherry, and mahaleb cherry ripen in the spring or early in the summer. Some of the best of the fruits that ripen later are the elder, wild cherry, chokecherry, the flowering dogwood and other cornels, the black haw and other viburnums, the Virginia creeper, and the climbing bittersweet. Some foreign species that may be obtained from nurseries are very fine for birds. Among these are honeysuckles of different kinds, especially the Tartarian honeysuckle, the hawthorn, the larch, the Japanese rose, and the Japanese flowering crab. Old apple trees, cherry trees, and black-berry, raspberry, currant, and other bushes whose fruit we prize are of use to the birds.

APPENDIX

DIMENSIONS OF NESTING BOXES

As given in Farmers' Bulletin 609, U. S. Department of Agriculture

SPECIES	FLOOR OF CAV- ITY	DEPTH OF CAV- ITY	ENTRANCE ABOVE FLOOR	DIAMETER OF ENTRANCE	HEIGHT ABOVE GROUND
	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Feet</i>
Bluebird	5 by 5	8	6	1 $\frac{1}{2}$	5 to 10
Robin	6 by 8	8	*	*	6 to 15
Chickadee	4 by 4	8 to 10	8	1 $\frac{1}{8}$	6 to 15
Tufted titmouse	4 by 4	8 to 10	8	1 $\frac{1}{4}$	6 to 15
White-breasted nuthatch	4 by 4	8 to 10	8	1 $\frac{1}{4}$	12 to 20
House wren	4 by 4	6 to 8	1 to 6	6	6 to 10
Bewick wren	4 by 4	6 to 8	1 to 6	1	6 to 10
Carolina wren	4 by 4	6 to 8	1 to 6	1 $\frac{1}{8}$	6 to 10
Dipper	6 by 6	6	1	3	1 to 3
Violet-green swallow	5 by 5	6	1 to 6	1 $\frac{1}{2}$	10 to 15
Tree swallow	5 by 5	6	1 to 6	1 $\frac{1}{2}$	10 to 15
Barn swallow	6 by 6	6	*	*	8 to 12
Martin	6 by 6	6	1	2 $\frac{1}{2}$	15 to 20
Song sparrow	6 by 6	6	†	†	1 to 3
House finch	6 by 6	6	4	2	8 to 12
Phoebe	6 by 6	6		*	8 to 12
Crested flycatcher	6 by 6	8 to 10	8	2	8 to 20
Flicker	7 by 7	16 to 18	16	2 $\frac{1}{2}$	6 to 20
Red-headed woodpecker	6 by 6	12 to 15	12	2	12 to 20
Golden-fronted woodpecker	6 by 6	12 to 15	12	2	12 to 20
Hairy woodpecker	6 by 6	12 to 15	12	1 $\frac{1}{2}$	12 to 20
Downy woodpecker	4 by 4	8 to 10	8	1 $\frac{1}{4}$	6 to 20
Screech owl	8 by 8	12 to 15	12	3	10 to 30
Sparrow hawk	8 by 8	12 to 15	12	3	10 to 30
Saw-whet owl	6 by 6	10 to 12	10	2 $\frac{1}{2}$	12 to 20
Barn owl	10 by 18	15 to 18	4	6	12 to 18
Wood duck	10 by 18	10 to 15	3	6	4 to 20

* One or more sides open.

† All sides open.

QUESTIONS ABOUT BIRDS

1. Of the various birds to be seen in the vicinity of your home, name the three species which you consider the most useful and give your reasons.

2. Name several kinds of birds that rob the nests of other birds.

3. Name several kinds that prey upon other birds.

4. What mammals and reptiles catch birds?

5. Name other things that cause the death of birds or interfere with their rearing young.

6. How fast would English sparrows increase if they were supplied with abundant food and had no enemies?

7. Describe a good trap for English sparrows. If other birds are caught in such a trap, can they be released unharmed?

8. Which birds are the earliest and which are the latest to nest in your locality?

9. What birds act as if wounded in order to lead an intruder away from their nests?

10. Name some kinds of birds that use mud in making their nests. How do they carry it?

11. Name all the birds which you know to occupy bird boxes. What are some points to be observed in making and placing these boxes to suit the birds?

12. Do all birds migrate?

13. Name all the birds which you have seen in winter. Why do not more of them remain all winter?

14. Are the woodpeckers and other birds you see in winter the same individuals you saw in summer, or have those gone farther south?

15. Classify several birds as the ruby-crowned kinglet was classified.

16. Name five birds that belong to orders of which no examples are mentioned in this book.

17. About how many species of birds are there in the world?

18. Why are turkey buzzards no longer protected in some states?

19. What birds have increased in numbers? How do you account for their increase?

20. Has the national law protecting migrating birds done any good?

21. What foreign birds have been introduced into North America? Which ones have multiplied here? Which ones are useful?

22. Name a bird that formerly migrated in larger flocks than any kind mentioned in this book, but is no longer seen. What caused it to become extinct?

23. Name some birds that were formerly abundant but have now become rare.

24. What clubs or societies promote the increase of useful birds? What means do they employ? What do they accomplish?

25. How are Nature Study Clubs organized? Do they make field trips?

26. If you were selecting glasses to use in observing birds, what points would you consider besides their magnifying power?

27. What is the best time of day for observing birds?

28. Name the birds you would expect to see in the woods; in a pasture; around a farmhouse; in a city.

29. What birds sing most in the morning, and what ones sing most in the evening?

30. Do the voices of birds of the same species show any difference?

31. Do birds give alarm notes or calls for help?

32. Read about penguins; the dodo; the great auk; the birds of Paradise.

A LIST OF BOOKS ON BIRDS

- Bailey, Florence Merriam. *Birds of Village and Field*. 406 pages. Houghton Mifflin Company, Boston. Gives keys for identifying the land birds, with descriptions of appearance and habits.
- *Handbook of Birds of the Western United States*. 570 pages. Houghton Mifflin Company, Boston. Covers territory from the Great Plains to the Pacific Ocean; useful for students in the West.
- Blanchan, Neltje. *Birds That Every Child Should Know*. 281 pages. Doubleday, Page & Co., Garden City, New York. Adapted to the use of the young child. Beautiful illustrations in black and white.
- *Bird Neighbors*. 234 pages, 48 colored plates. Doubleday, Page & Co., Garden City, New York. An introductory acquaintance with 150 of our most common birds.
- Chapman, Frank M. *Bird Life*. 283 pages. D. Appleton & Co., New York. A guide to the study of our common birds. Has 75 full-page colored plates after drawings by Ernest Thompson Seton.
- *Birds of Eastern North America*. 530 pages. D. Appleton & Co., New York. Describes all the species of birds of region covered.
- Finley, William L. *American Birds Studied and Photographed from Life*. 256 pages. Charles Scribner's Sons, New York.
- Forbush, Edward H. *Useful Birds and Their Protection*. 2 vols., 451 pages each. Massachusetts State Board of Agriculture, Boston. Contains illustrations of noxious insects and the birds that feed on them, with descriptions of their habits.
- Herrick, Francis H. *The Home Life of Wild Birds*. 255 pages. G. P. Putnam's Sons, New York. Has good illustrations.
- Job, H. K. *How to Study Birds*. 272 pages. Outing Publishing Company, New York. A practical guide for amateur bird-lovers.
- Pearson, T. Gilbert. *A Bird Study Book*. 258 pages. Doubleday, Page & Co., Garden City, New York. Treats of the domestic life and migration of the birds and what is being done to protect them.
- Reed, Chester A. *Birds of Eastern North America*. 456 pages. Doubleday, Page & Co., Garden City, New York. Contains small colored illustrations of every species common to the United States and Canada, from the Atlantic Coast to the Rockies.
- Trafton, Gilbert H. *Methods of Attracting Birds*. 171 pages. Houghton Mifflin Company, Boston. Contains illustrations of bird houses and shows how grounds may be made inviting to birds.
- Wright, Mabel Osgood. *Birdcraft*. 317 pages. The Macmillan Company, New York. A field book of 200 song, game, and water birds, with 80 full-page plates. Keys for identifying birds are included.



SCARLET TANAGER
Male and Female



CARDINAL
Male and Female



BALTIMORE ORIOLE
Male and Female



RUBY-THROATED HUMMING BIRD



CEDAR WAXWING



TOWHEE



BLUEBIRD



ROBIN



RUSSET-BACKED THRUSH



RUBY-CROWNED KINGLET



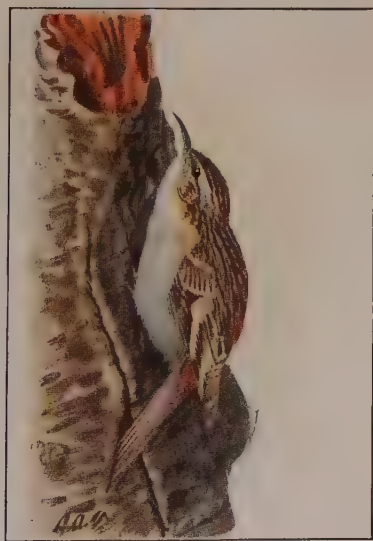
CHICKADEE



WHITE-BREASTED NUTHATCH



RED-BREASTED NUTHATCH



BROWN CREEPER



HOUSE WREN



BROWN THRASHER



CATBIRD



MOCKING BIRD



MYRTLE WARBLER



LOGGERHEAD SHRIKE



PURPLE MARTIN



BARN SWALLOW



SONG SPARROW



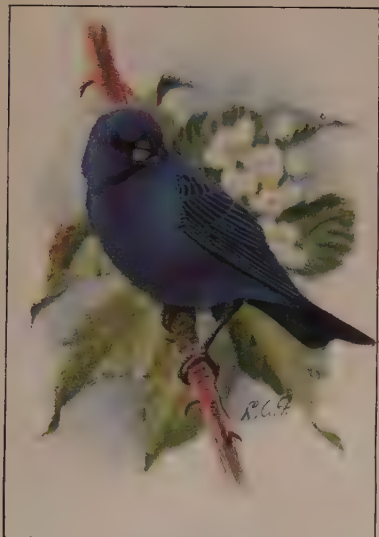
ENGLISH SPARROW



CHIPPING SPARROW



WHITE-CROWNED SPARROW



INDIGO BUNTING



GOLDFINCH



BLACK-HEADED GROSBEEK



ROSE-BREASTED GROSBEEK



CROW BLACKBIRD



RED-WINGED BLACKBIRD



MEADOW LARK



HORNED LARK



BOBOLINK



BULLOCK'S ORIOLE



CROW



BLUE JAY



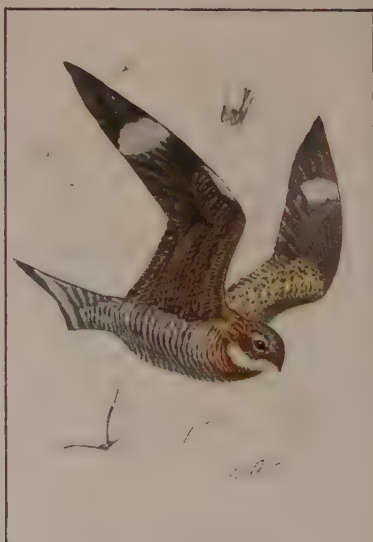
CALIFORNIA JAY



ARKANSAS KINGBIRD



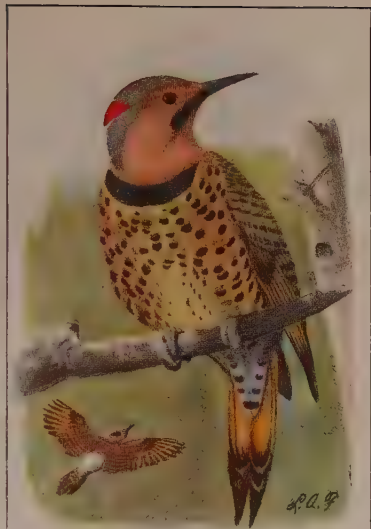
KINGBIRD



NIGHTHAWK



DOWNY WOODPECKER



FLICKER



YELLOW-BELLIED SAPSUCKER



YELLOW-BILLED CUCKOO



SPARROW HAWK



SCREECH OWL



RED-TAILED HAWK



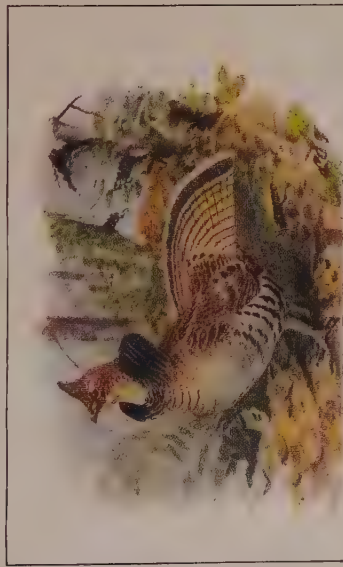
BARN OWL



COOPER'S HAWK



MOORNING DOVE



RUFFED GROUSE



BOBWWHITE



BLACK TERN



KILLDEER



FRANKLIN'S GULL



BARTRAMIAN SANDPIPER

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